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MUNGBEAN IN CROPPING SYSTEM IN CENTRAL THAILAND

TECHNICAL BULLETIN NO. 1

ISSUED BY

THE MULTIPLE CROPPING RESEARCH PROJECT

FACULTY OF AGRICULTURE
KASETSART UNIVERSITY
BANGKOK THAILAND
NOVEMBER 1979

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INTRODUCTION

Mungbean is one of the most important food crops in Asian diets. It has been grown in most part of tropical countries as well as Thailand. In the past, mungbean were grown in small areas for local consumption. Large scale production was not practiced due to limited market. Recently, there has been quite a strong demand for mungbean export especially to Japan, therefore, area of mungbean production has increased substantially and farmers realized that they could increase their income by growing mungbean as well as improved their diet.

Mungbean also provide an excellent source of protein for human diet. Its particular use fulness as fortifiers of cereal grain for children. Researches had proven that cereals are inadequate in protein to support the normal growth and development, therefore, children need substantial amount of protein which can be provided cheaply and practically by legume crops like mungbean. In some countries where starchy root crop is a major source of food, the use of vegetable legumes like mungbean become the major important dietary protein source.

The Multiple Cropping Research Project of Kasetsart University, Faculty of Agriculture has been working in the selected district, Bangpae, Rachaburi Province since 1977. Researches were conducted in the farmer' fields in order to identify the suitable cropping pattern which farmers in that particular area can adopted. The project anticipate that cropping pattern which proved suitable for Bangpae district can be introduced to other provinces in Central Thailand which has an agro-climatic zone similar to Bangpae district. Furthermore, the project aim for searching ways in which the yield of crops grown in the particular cropping pattern can be increased. Therefore, staffs and researchers from various source of interdisciplinary team work together in this particular system research forming an integrated multiple cropping program.

Results of cropping pattern study in 1977-1978 had indicated that mungbean can be successfully grown in rice based cropping system before and after rice was planted in rainfed condition. In order to be able to increase yield and production, suitable methods of mungbean production and protection should be employed. Thus, researches in mungbean production, weed control, soil science, entomological study as well as cropping system testing were conducted. Results of our preliminary researches were reports in this technical bulletin.

The staff of the Multiple Cropping Project would like to thank the International Development Research Center-Canada (IDRC) for the financial support. The help and cooperation of the Faculty of Agriculture, Department of Agronomy, Soil Science, Entomology, are highly appreciated. Special credit for this work goes to research assistants and village assistants who have been working tremendously hard for the project. Without them, all researches would not have been carried on in such a way that reports are presented in this technical bulletin.

Aroon Chantanao

Director

Multiple Cropping Research Project.

RICE BASED CROPPING SYSTEM INVOLVE MUNGBEAN IN CENTRAL THAILAND

BY

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Vinich Sereeprasert and Worakarn Pinya are research assistants of the Multiple cropping research project responsible for field testing in the outreach areas.

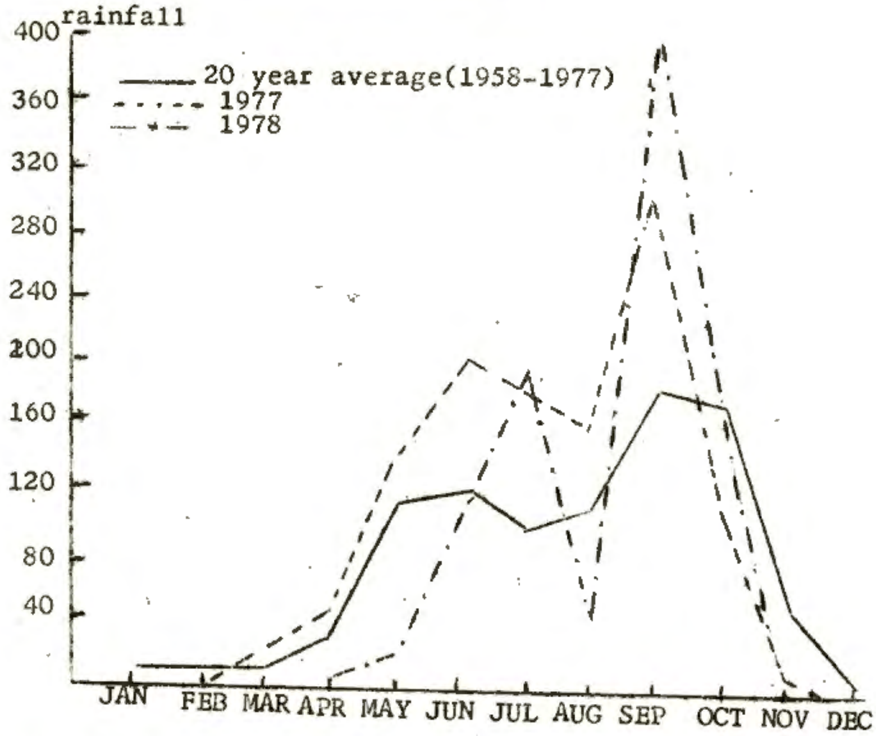
RICE BASED CROPPING SYSTEM INVOLVE MUNGBEAN IN CENTRAL THAILAND

INTRODUCTION

Mungbean (Vigna radiata (L.)Wilezek) is one of the important crop suitable for growing before and after rice in cropping system program. It is either row-planted or broadcasted in the non-irrigated area before rice has been planted or planted after rice crop using residual soil moisture. In the irrigated area of northern Thailand, mungbean is usually grown during summer in the cropping system program involve with garlic-mungbean-rice. It is seldom fertilized or inoculated. Residual fertility from the previous well fertilized garlic crop was utilized by subsequent mungbean crop (2).

When Kasetsart University, Multiple Cropping Research Project initiate its outreach research activities at Bangpae district Rachaburi Province located approximately 100 kilometers southwest of Bangkok, local variety of mungbean were grown by some farmers before rice with very little input given interm of land preparation and cultivation (1). Rainfall in Bangpae which begin during the first week of May seems to be ample for mungbean growth before rice crop. Normally rainfall cease towards the end of October while rice is harvested in December. Farmers normally leave the land fallow after rice has been harvested and wait for months before they begin to plant any crop again when the rain came (1) Rainfall pattern of Bangpae was shown in Figure 1.

Figure 1. Monthly rainfall at Bangpae



I. MUNGBEAN PATTERN TESTING BEFORE RICE CROP

I.1 Materials and Methods.

During May-August, 1977, superimposed experiments 1/ planted with mungbean were grown in the farmer fields in Bangpae district. The experiment conducted involved broadcating and row planting of mungbean with and without fertilizer gimen, different kind of insecticides spraying in mungbean and variety comparison between M7A and local mungbean variety. The seed yield and yield components of mungbean in those experiments were shown in Table 1.

1/ Superimposed experiments are those trials with four replications run across village (i.e. replication 1 is conducted in the farmer field in village A while replication 2 is located in village B. the size of each plot is large enough for economic evaluation of cash input and return (normally 1600 sq.m.)

In May, 1978 a cropping pattern experiment consisted of 4 crops and two intercrop practices were tested in the farmer fields at Bangpae with the objective of finding a suitable crop which can be grown before rice in that particular area. The pattern tested consisted of the following.

1. Mungbean variety M7A
2. Soybean variety S.J.2
3. Sweet corn variety Supersweet D.M.R.
4. Glutinous corn
5. Mungbean intercrop with sweet corn.
6. Soybean intercrop with glutinous corn.

The design of the experiments was randomized complete block with 6 replications. Replications were run across the farmer fields in the same manner as mungbean experiment before rice in 1977. All crops were planted using three planting date, 1 st May, 10 th May and 17 th May respectively except for glutinous corn in which the planting date were 18 th May, 28 th May and 30 th May. All plot size range from 150-200 sq.m.

Basal fertilizer at the rate of 50 and 62.4 Kg.N and P_2O_5/ha respectively was applied using 16-20-0 mixed fertilizer. Alachlor (Lasso 43.3 % EC) was applied as preemergence herbicide at the rate of 2.15 Kg ai/ha im mediately after the seed was planted.

In monoculture, mungbean was planted at the rate of 25 Kg/ha by drilling the seeds. Soybean, sweet corn and glutinous corn were planted at the spacing of 12.5 x 50 cm and 25 x 75 cm. respectively. In the intercrop plots, corn was planted using the spacing of 25 x 75 cm. while soybean and mungbean were planted in between using the spacing of 12.5 cm. between hill for soybean and drilling the seed at the rate of 12 Kg/ha for mungbean.

1.2 Results and Discussion

The seed yield and yield components of mungbean grown in 1977 before rice crop are shown in Table 1. The yield of mungbean and other field crops grown alone and intercrop with each other in 1978 before rice growing season are shown in Table 2 and 3 respectively. The data of mungbean in 1977 crop reveal that the yield advantage of 135 Kg/ha.of mungbean can be obtain when seeds are planted in rows when compared to broadcasting method ($p < 0.05$). However there was no yield advantage from using fertilizer in mungbean when compared to the yield of plots receiving no fertilizer. Similar results were also obtained between insecticide plots and control.

Table 1. Seed yield and some of the yield components of mungbean grown before rice crop in 1977.

Kind of treatment	Level of treatments	Seed yield 1/ (Kg/ha)	No. pod 1/ /plant	No. Seeds 1/ /pod
Broadcast 4/	without fertilizer	287.5	11.0	11.6
	with fertilizer 2/	297.5	9.8	12.0
	Means.	292.5		
Row planting 4/	without fertilizer	412.5	10.0	11.8
	with fertilizer	442.5	10.0	11.9
	Means	427.5		
Insecticide	without insecticide	466.0	no data collected	
	with insecticide 3/	558.3	"	
	Means.	512.1		
Varieties	M7A	537.5	10.6	9.8
	Local variety	281.2	6.7	11.2
	Means.	409.3		

1/ Means of 4 replications

2/ Mixed fertilizer 14-14-14 given as basal application at the rate of 26.25 kg. N, P_2O_5 and K_2O/ha.

3/ Means of three insecticide treatments namely Furadan 3 G at 1.5 kg a.i./ha applied twice at 3 weeks interval. Phosdrin 24 % E.C at the rate of 0.5 kg a.i./ha sprayed three times at 2 weeks interval. Lannate 18 % W/V at the rate of 0.36 kg a.i./ha, sprayed three times at 2 weeks interval.

4/ Broadcast treatment involve mungbean planted at seeding rate of 25 kg/ha while in row planting treatment, furrows were made at 60 cm. apart after ploughing and harrowing and seed was drilled evenly in the furrow at the rate of 25 kg/ha.

Table 2. Yield of crops grown before rice at Bangpae in 1978.

Crops and intercrop combination	Yield	Remarks
I Mono culture		
1.1 Mungbean (M7A)	277.1 kg/ha	seed yield
1.2 Soybean (S.J.2)	12134.4 kg/ha	stem + pod harvested green
1.3 Sweetcorn(Supersweet DMR)	17458 cobs/ha	cobs harvested green
1.4 Glutinous corn(Local)	-	field were destroyed by flood due to late planting
II Mungbean intercrop with sweet corn		
2.1 Mungbean	118.7 kg/ha	seed yield
2.2 Sweet corn	16708 cobs/ha	cobs harvested green
III Soybean intercrop with sweet corn		
3.1 Soybean	6000 kg/ha	stem + pod harvested green
3.2 Sweet corn	17083 cobs/ha	cobs harvested green.

*/ means across 6 replication and 3 planting dates.

Table 3. Growth and yield components of mungbean grown alone and intercrop with sweet corn as affected by planting dates

Mungbean growing alone

Planting date	Yield (kg/ha)	No.pod/plant	100-seed weight (g)
1 May	312.5	8.3	4.97
10 May	262.5	7.4	5.19
17 May	350.0	15.4	5.50

Intercrop mungbean with sweet corn

Planting date	Yield (kg/ha)	No.pod/plant	100-seed weight (g)
1 May	75.0	2.4	5.19
10 May	181.2	2.5	4.78
17 May	100.0	5.7	6.16

In the experiment in 1977, it has been shown that mungbean variety M7A gave higher yield than local mungbean variety. M7A variety was introduced by the Department of Agriculture. We had observed in our experiments that the yield advantage of M7A over local variety was cause by high number of pods per plant (Table 1) while seed size was generally the same. In our observation, M7A showed less degree of infection to cercospora leaf spot diseass cause by Cercospora canescens and powdery mildew caused by Erysiphe polygoni.

Pods of M7A variety mature more uniformly than local mungbean and farmers normally harvest M7A crop only twice while in local mungbean variety, it took four times for farmers to harvest their crops.

By growing mungbean together with other crops such as soybean and corn in 1978 in pattern testing experiment, it was found that mungbean is more suitable to short growing season before rice could be planted at Bangpae than soybean. In 1978, rainfall started in early May, increased its amount gradually until reaching the first peak in middle of June. Farmer normally transplant rice in late July or early August. Therefore, an upland crop which can be grown before rice has to be planted in May and harvested in early July before the field is flooded. M7A mungbean which mature 60-65 days before planting was found to be suitable to grow before rice in this manner. Soybean can be grown for green pod production in which market is quite limited but it can not be grown for seed due to its longer maturity period. Sweet corn which can be harveste 65-70 days after planting was also found to be suitable crop before rice at Bangpae. The only drawback to sweet corn production in these area was the downy mildew disease which was widespread and detroy almost all farmer corns in 1978. Although we used supersweet DMR resistant variety, we still obtain as high as 40 percent disease infection in our test plot.

The fact that yield of mungbean in 1978 was lower than 1977 could be due to insect damage to most of mungbean field in this particular year. In monoculture, it was found that growing mungbean as late as 17 May is possible because mungbean can be harvested on 20 July before flooding occured. Yield of mungbean grown as late as 17 May was significantly higher than growing the 2 nd planting date ($P < o.05$). It may due to the fact that rainfall intensity in early July was ample for mungbean grown in this third planting date to take advantage for its pod setting and seed filling period. Our data in Table 3 showed higher number of pods and seed size (100 seed weight) in the third planting date treatment when compared to other two planting dates.

Yield and yield components of mungbean intercrop with sweet corn were generally low (Table 2,3), corn yield in the intercropping plot was not significantly lower than monoculture. However, the cause of low yield of mungbean in intercropping plot may be due to the shadding effect of corn to mungbean

2. MUNGBEAN PATTERN TESTING AFTER RICE CROP

2.1 Materials and Methods.

Sixteen plots of mungbean with the plot size range from 750-1000 sq.m. were planted in early January 1978 after rice had been harvested. The experiments composed of 4 replications running across village and four treatments were tested as follows:

1. Broadcasting mungbean at the seed rate of 37.5 kg/ha without applying insecticide (Broadcasting-without insecticide)
2. Broadcasting mungbean at the seed rate of 37.5 kg/ha plus insecticide given (Broadcasting-with insecticide)

3. Planting mungbean in rows after ploughing and harrowing at the seed rate of 37.5 kg/ha.(Conventional tillage-row planting)
4. Planting mungbean in rows without previous land preparation at the seed rate of 37.5 kg/ha(No tillage-row planting)

All the plots received neither herbicide nor fertilizer. In broadcast plots, seeds were broadcasted to the ground with no previous land preparation. After seeds had been broadcasted the land was ploughed once just to cover the seeds. In treatment 3 the land had been plough and harrow once before rows were opened and seeds were drilled in rows. In treatment 4, rows were opened and seeds were drilled in rows without land preparation. Plants were harvested from 20 sq.m. harvested area from each plots. All plots were harvested not later than March 26, 1978.

In December 1978, two mungbean experiments were tested in the farmers field at Bangpae. In the first experiments, the crops were planted on December 13, December 21, December 25, 1977 and January 8, 1978 as planting date I,II,III and IV. Mungbean variety M7A were evenly broadcasted with the rate of 37.5 kg/ha into 12 plots followed by one ploughing operation after rice had been harvested. The plot size range from 750-1000 sq.m., they were replicated three time across the village. Date of flowering, harvesting date, plant height and yield were recorded.

In the second experiments, methods of planting such as broadcasting and planting in row at the same density with and without applying pre-emergence herbicide were tested. In the herbicide given plots, the plant received Alachlor (Lasso 43.3%B.C.) at the rate of 2.15 kg a.i./ha immediatly after seed were sown. In broadcasting plots, the land was plough after seeds had been sown while in row planting plot, land was plough and harrowed once, then seed were sown in rows. Yield were recorded from 20 sq.m. harvest plot.

Table 4. Yield of mungbean, var. M7A in different culture practice treatments in 1977 after rice season.

Treatement	seed yield kg/ha 1/	No. pod/plant
Broadcasting without insecticide	404.0 [a]	9.9
Broadcasting with insecticide 2/	528.8 [a]	10.7
Conventional tillage-row planting	579.1 [a]	10.4
No-tillage-row planting	714.3 [b]	11.5

1/ Means of 4 replications

2/ In the insecticide treated plots. Three insecticides were tested namely.

Azodrin 168 BC (Monocrotophos) at the rate of 1 kg a.i./ha

Phosdrin 18 % EC (mevinphos) at the rate of 1 kg a.i./ha

Lannate 20 % EC (methomyl) at the rate of 0.2 kg a.i./ha

All insecticides were given at the three weeks interval starting one week after planting. Data obtained were means yield of three insecticide treatments which had been showed no significant difference.

Table 5. Days to flower, day to maturity, plant height and seed yield of M7A mungbean grown after rice in 1978 crop year (Means of three replications)

Planting date		Day to flower	Day to maturity	Plant height at flowering (cm.)	Seed yield kg/ha
I	- 13 Dec, 1978	36	60	26.5	781.6
II	- 21 Dec, 1978	38	62	27.5	445.4 */
III	- 25 Dec, 1978	38	59	24.5	609.2
IV	- 8 Jan, 1979	37	63	26.0	585.5

*/ Plots were attack severely by insects.

Table 6. Yield of mungbean var. M7A(kg/ha) in different method of planting

	Replication I	Replication II	Mean
Broadcasting - without herbicide	663.0	705.0	684.00
Broadcasting - with herbicide	802.0	903.0	852.50
			768.25
Row planting - without herbicide	590.0	540.0	567.00
Row planting - with herbicide	772.0	783.0	777.50
			672.25

2.2 Results and Discussion

From the mungbean data appeared in Table 4,5 and 6, it has been shown that, mungbean can be grown after rice crop in Bangpae without irrigation supply. The yield of M7A mungbean ranged between 404-714 kg/ha in 1977 crop year(Table 4) and 445-852 in 1978 crop year. Growing mungbean after rice at Bangpae was possible through broadcarting seeds followed by ploughing once to cover the seeds. Unlike growing mungbean before rice crop, planting mungbean in row after ploughing and harrowing did not gain any yield advantage in both 1977 and 1978 crop year (Table 4 and 5). However growing mungbean in row without land preparation (No tillage practice) gave significantly higher yield ($P > 0.05$) when compared to broadcasting and row planting with conventional tillage in 1977 (Table 4)

From the data in table 4,5 and 6, it appeared that mungbean growth in farmers field after rice crop depend upon residual soil moisture left after rice had been grown. In Bangpae, rainfall ceased at the end of October and early November in both 1977 and 1978. There was no supplement irrigation given to those plots during the period in which these crop had been grown.

In a seperate experiment on the effect of surface management on soil moisture profile on a paddy soil at Bangpae, Visoot Verasan and Yongyuth Osotsapar (1977) reported that the moisture equivalent (% by weight) of soil at Bangpae ranged from 15-25 percent in their experimental plots (Figure 2). This amount of moisture was used for mungbean growth between January 26 to April 8. In their experiment, yield of mungbean in no tillage practice was higher than conventional tillage plots when both plots were planted in row. The moisture profile and double weight average of soil moisture content were higher in no tillage plot than tillage plot (Table 7). Therefore land preparation during the period after rice may cause the lost in soil moisture which will, in turn, effect the mungbean yield.

Our results in 1977 and 1978 experiments showed that there was yield advantage in no-tillage plots when compare to conventional tillage, however, there was no yield difference between broadcasting and row planting in which the latter require land preparation before seeds were drilled. Broadcasting methods which had been practices at Bangpae may result in better moisture conservation than conventional tillage with row-planting under the condition inwhich moisture is limited. Our result from planting date experiment did not indicate any significant yield decrease when the crop was planted late in the season. However, the decrease in yield from 781 to 585 kg/ha when planting was delayed nearly a month may reflect the decrease in soil moisture content.

Planting mungbean after rice need better control for insect. Using insecticide gave the yield advantage of 124 kg/ha in 1977 (Table 4). The data in 1978 also showed that spraying mungbean periodically with Azodrin resulted to high yield of mungbean when compared with no-insecticide plot. The plot received no Azodrin yield only 395 kg/ha with severe leaves and pod damage cause by insect. Azodrin spraying yield 813 kg/ha with less insect damage.

SUMMARY

In short growing season before rice was planted at non-irrigated area such as Bangpae distsict, southwest of Bangkok, a short growing crop like mungbean which mature in 60 days was found suitable as an upland crop before rice. Planting mungbean in rows gave yield advantage of 135 kg./ha over broadcasting method while M7A variety, which was introduced by Department of Agriculture performed bdfter than local variety.

Mungbean was also found suitable in this area after rice has been harvested with out irrigation supply. Residual soil moisture, was utilized by mungbean growth until the crop reach maturity then depleted. Hence, other crops which required higher amount moisture and mature later such as soybean and corn could not be grown at this particular time of the year. Conventional tillage help deplete residual soil moisture, thus, broadcasting mungbean followed by single ploughing just to cover the seed and no tillage planting were found suitable for growing mungbean after rice.

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Table 7. Double weight average of soil moisture content (% by weight) throughout soil profile throughout the growing period and yield of mungbean (kg/ha)

Replication	Treatment combination			
	1	2	3	4
1	21.92 *	23.05*	22.53 *	21.69*
	(514.29)	(577.14)	(748.57)	(742.86)
2	20.19	19.19	19.11	20.83
	(271.43)	(285.71)	(442.86)	(685.71)
Average	20.99	21.11	20.79	21.26
	(392.86)	(431.43)	(595.72)	(714.29)

Treatment combination:

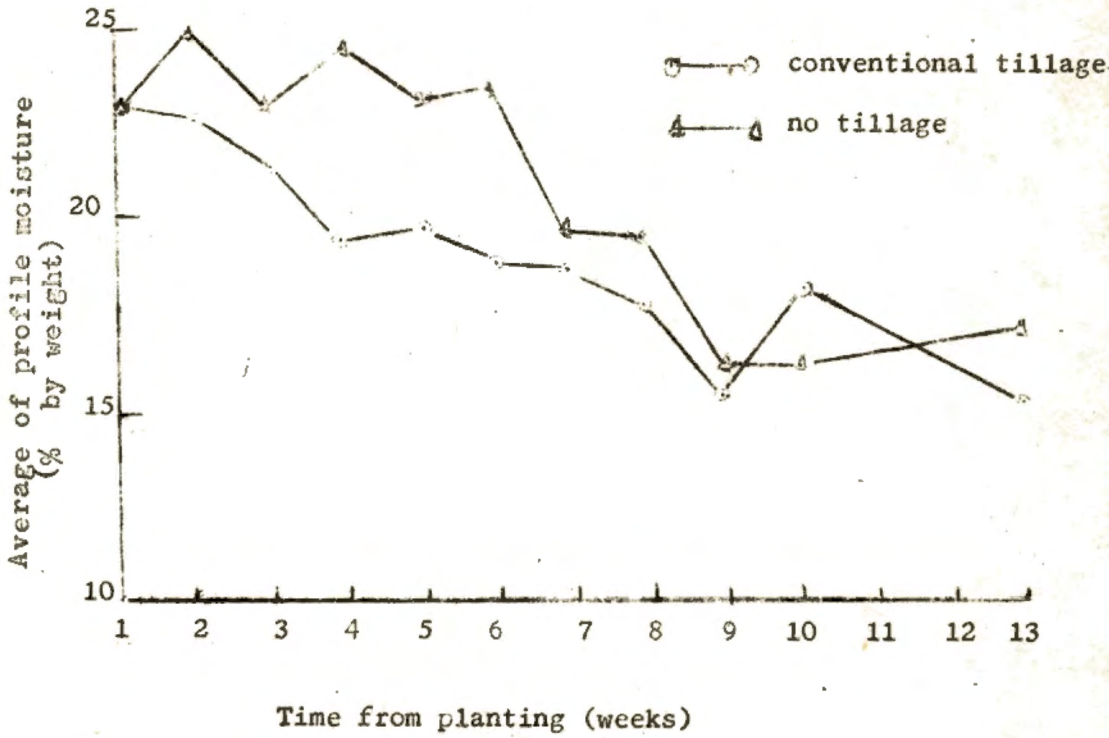
1. Straw burned, conventional tillage
2. Straw burned, no tillage
3. Straw left, conventional tillage
4. Straw left, no tillage

* Under influenced of lateral seepage

figure in parenthesis = mungbean yield

(adopted from Annual report cropping systems (Thailand) project 1977 page 118-119. Kasetsart University, Ministry of Agriculture and cooperatives and International Development Research Centre)

Figure 2. Average of profile moisture throughout the growing season in conventional tillage and no tillage plots.



COMPONENT OF GROWTH AND YIELD OF MUNGBEAN WHEN GROWN AFTER RICE IN CROPPING SYSTEM

BY

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COMPONENTS OF GROWTH AND YIELD OF MUNGBEAN WHEN GROWN AFTER RICE IN CROPPING SYSTEM

INTRODUCTION

Mungbean (Vigna radiata (L.) Wilczek) is considered as an important upland crop grown in the rice based cropping system before and after rice crop. In Bangpae district which is 100 kgm. south of Bangkok, mungbean is grown after rice has been harvested in early January.[3] Residual soil moisture is the only source of moisture supply in mungbean during that period. Generally, farmers grow this crop under low management system in which the seeds were broadcasted in the field as soon as rice had been harvested follow by single ploughing barely enough to cover the seed. Neither fertilizer nor herbicide was given to mungbean particularly during this time of the year.

This paper reports the experiments in mungbean which were conducted in order to study its growth particularly when crops were grown by broadcasting and row planting. These informations may be benificial to researchers who attempt to improve mungbean yield particularly under rainfed condition similar to Bangpae area.

MATERIALS AND METHODS

The experiments were conducted in farmer field between March 14-May 26, 1978 for 1978 experiment and between January 11-March 28, 1979 for 1979 experiment. The soil is an alluvial deposit with clayey in texture and high water holding capacity. pH is 6.0 with 3.0 percent organic matter with 30 and 80 ppm of Pand K. In both experiments previous rice crop was harvested approximately one week earlier.

In 1978 experiments. mungbean variety M7A was planted into four plots 82.5 sq.m. in size. Seeds were drilled in rows 50 cm. apart. Land was prepared by flooding 10 days before ploughing and harrowing prior to planting seed. Ammonium sulphate, super phosphate and muriate of potash were basally applied at the rate of 12.5, 75 and 75 kg/ha. After emergence, plants were thinned to obtain the plant population of 626,000 plants/ha. In 1979 experiments, a split plot design with four replications were used. Planting mungbean by broadcasting and row planting were two main plots, and plant population of 150,000, 200,000 and 250,000 plants/ha. were sub plots. To establish a given population, seeds were either broadcasted or row planted at the rate of 100,150 and 200 g./plot. Individual plot size was 42 sq.m with 30 sq.m harvest area. After emergence, plants were thinned to achieve a given population 16-20-0 fertilizers were given at the rate of 50 kg.N/ha before planting.

In both experiments, crops were grown for 60 days, and during such period, 5-6 destructive plant samples were taken. At each sampling date, six plants were taken from each plots, number of leaves, nodes inflorescence and flower numbers, number of pods and seeds were counted and calculated per plant basis. Total dry matter and dry weight of different plant parts were taken including leaf area measurement which was done at beginning flowering and complete flowering.

RESULTS AND DISCUSSION

In both 1978 and 1979 experiments, yield per unit area were not reported due to serious attack of disease caused by Scherotium rolfsii and pod rot caused by Dipodia sp. which occurred after mid pod fill stage. We observed that pod rot occurred severely in 1978 while Scherotium wilt occurred in 1979. Plot uniformity were largely affected, therefore yield per unit area were not measured.

Mungbean variety M7A were grown for 60 days, day to flower range between 32-36 days in both years. Flower duration were between 9-12 days (Table 1). From our observation, growth duration period were similar except day to flower which were slighly longer in 1979. Vegetative growth of mungbean in both years range between 32-36 days.

Day to flower of mungbean in 1978 and 1979 years were similar to the finding by Ng Thai Tsiung (4) who reported that mungbean grown in Sarawak flowered at 33 days after sowing regardless of sowing date. Growth of 1979crop was poorer than 1978 as indicated by lower plant height and total dry matter production (Table 2).

Our first intention was to establish 1979 experiment in order to achieve high population density as 600,000 plants/ha similar to 1978 experiment. However, a maximum plant density which obtained from broadcasting 47.6 kg/ha of seeds was only 250,000 plants/ha. Therefore, we had to adjust density in row planting treatments along with broadcasting plots. In 1979 experiment, soil preparation was not adequate done as 1978 crop due to the breakdown of impliment during that time, soil crusting plus limited amount of soil moisture was probably the mainfactor reducing stand heavily. This is the reason why leaf area index (LAI) value which obtained in 1979 were much lower than 1978 (Table 2).

Table 1. Duration of mungbean growth after rice in 1978 and 1979

Growth Stages	1978 Expt.	1979 Expt.
Planting date	March 14	January 19
Emergence date	March 25	January 26
Flowering date	April 26	March 3
Flowering completed	May 5	March 15
Harvesting date	May 25	March 27
Day to flower	32 days	36 days
Flowering period	9 days	12 days
Day to maturity	60 days	60 days

Table 2. Comparison between growth and yield components of mungbeans in 1978 and 1979 experiments

Component of Growth and Yield	1978 Expt.	1979 Expt.
Plant height (cm.) at complete flowering	27.5	25.3
Total dry matter(gm/plant)at mid pod filled	6.6	4.44
Leaf area/plant(cm^2) at complete flowering	1273.97	230.30
Leaf area index	7.75	0.46
No. pod/plant at harvest	10.20	15.62*
No. seed/plant at harvest	7.40	25.10*
100. seed weight	6.20	5.54

*/ Average from three plant population treatments in both broadcasting and row planting methods

In both years, mungbean produced 5 trifoliate leaves on the main stem before flowering. Branching were restricted either by high density in 1978 or by low dry matter production caused by drought in 1979. Three to four inflorescences per plant produced flowers. Number of nodes and plant height increase from emergence date, reaching maximum at complete flowering and remain constant afterward. Maximum node number and plant height were 8.3 and 37.7 cm. respectively.

Dry matter production of mungbean including percent dry weight of different plant parts were shown in Table 3. Root weight comprised of not more than 10 percent of total plant dry weight. Root weight decrease its value slightly after complete flowering. The decrease in stem weight beginning 48 DAE while the increased in pod plus seed weight was pronounced could be due to the transfer of assimilate from vegetative portion to seed at seed filling period. Similarly, the decrease in leaf dry weight after completion of flower were caused by leaf drop and drymatter transfer of leaves to pod. Similar results were found in pea (Pisum sativam) and soybean (Glycine max) (1,2). Considering drymatter and plant height data in 1978, we may conclude that vegetative growth of mungbean ceased at the completion of flowering (approximately 41 DAE). At this point, plant height and number of node reach maximum at this date, while root, stem and leave dryweight gradually decreased with an increased in pod weight.

Planting mungbean by either broadcasting or row planting in 1979 did not significantly affect growth and yield components of mungbean in any plant population except for percent pod set which were higher in row planting than broadcasting ($P < 0.05$)(Table 4,5). Smaller plants particularly when they were grown under low density limit itself in expressing high potential up to

Table 3. Dry matter production of mungbean including percent dryweight of plant parts taken at different date in 1978 experiment.

Component of drymatter	20 DAE	27 DAE	28 DAE	41 DAE	48 DAE	55 DAE
Total drymatter (gm.)	.77	1.75	3.84	3.95	4.82	6.60
Root weight (%)	10.5	10.9	9.40	7.5	7.3	8.0
Stem weight (%)	35.0	35.0	44.2	46.3	37.3	32.7
Leaf weight (%)	54.5	53.9	46.4	38.8	27.4	29.0
Pod plus seed weight (%)	-	-	-	7.4	28.0	30.2

DAE = days after emergence

Table 4. Total dry matter and leaf area index of mungbean taken at different growth stage in 1979 experiments

Method of Planting	Plant Population	Leaf area $(cm)^2$ at flowering	Leaf area $(cm)^2$ at complete flowering	Total dry matter g./plant			
				30 DAE	37 DAE	52 DAE	60 DAE
	150,000	211.09	240.28	0.60	1.88	3.06	4.32
Broadcasting	200,000	220.72	258.31	0.56	1.31	2.96	4.59
	250,000	220.75	245.19	0.62	1.59	2.87	5.28
	150,000	221.96	213.31	0.56	1.65	4.40	4.08
Row-planting	200,000	187.09	218.87	0.57	1.42	3.14	3.88
	250,000	203.62	205.87	0.48	1.29	2.76	4.42

Table 5. Yield component of mungbean in 1979 experiments

Method of Planting	Plant Population	No.flower produced/ plant	% pod set	No. pod/ plant	No.seed/ 100 plant	Seed weight (g.)	Seed yield/ plant
	150,000	88	16.5	14.5	23	5.12	1.26
Broadcasting	200,000	89	16.8	15.0	28	5.47	1.63
	25,000	81	17.1	17.2	31	5.46	1.78
	150,000	80	22.0	17.5	24	5.12	1.25
Row-planting	200,000	78	18.6	14.5	21	5.80	1.24
	250,000	79	19.0	15.0	24	6.30	1.53
		N.S.	5 % for method of planting	N.S.	N.S.	N.S.	N.S.

the point in which competition may occeurred and would cause the different in growth and yield components among treatments. In other report of mungbean grown after rice at Bangpae, (5) it was also mentioned that row planting mungbean were not found to give advantageous when they were planted after rice simply because high density were not achieved during this particular period due to dry condition. Soil moisture could be better conserved if seeds were broadcasted before single ploughing or no tillage planting.

In conclusion, planting mungbean in order to achieve high density such as 626,000 plants/ha immediately after rice was harvested at Bangpae were difficult due to moisture limitation. Therefore, under low density, broadcasting or row-planting methods did not show any advantageous in growth and yield particularly when growth were limited by moisture. Mungbean experiments in 1978 were planted later in March in which irrigation supply were much better plus land was in better condition than 1979 experiment under such condition, high density and better growth were obtained

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EFFECT OF REPEAT PRE PLANT APPLICATION OF GLYPHOSATE ON PURPLE NUTSEDGE POPULATION IN MUNGBEAN RICE SEQUENTAL CROPPING

BY

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EFFECT OF REPEAT PREPLANT APPLICATION OF GLYPHOSATE ON PURPLE NUTSEDGE POPULATION IN MUNGBEAN-RICE SEQUENTIAL CROPPING

INTRODUCTION

Purple nutsedge (*Cyperus rotundus* L.) is one of the main weeds in rice field in the district of Bangpae, Rachaburi Province, as well as in many places in Thailand and such as Sanpatong district, Chiengmai. Eventhough the weed can be controlled by the common and cheap compound like 2,4-D or MCPA, but the effect is just temporary. The plant will re-sprout in 3 to 4 days after the top killed. In the circle of herbicides,so far, glyphosate (N-phosphonomethyl glycine) is found the best to deal with this kind of weed. The chemical is also highly effective against many perennial grasses, like lalang(*Imperata cylindrica*(L.)Beauv.) and torpedograss (*Panicum repens* L.). The chemical is systemic and foliarly applied. Under natural condition when contacted with the soil, the chemical is rapidly inactivated and slowly degraded by the soil microorganisms. Glyphosate is currently recommeded as preplant treatment in many crops such as corn sorghum and soybeans.

The objective of the experiment is to find out the effect of repeat application of glyphosate on the population of nutsedge in long term period, and also the effect of the chemical on mungbean and rice crops.

MATERIALS AND METHODS

The experiment consisted of 4 chemical treatments, i.e. glyphosate 0.8 kg/ha, 1.6 kg/ha, 0.8 + ammonium sulfate 10 kg/ha and glyphosate1.6 kg/ha + ammonium sulfate 10 kg/ha. The last 2 combinations were applied as tank mix. Two control treatments, hoe-weeded and non weeded, were also included. Because of high density of nutsedge population practically hoe-weeded control was just the same effect as un weeded control. Plot size was 4 x 4 m^2 arranged in randomized complete block design with 6 replications. In first application (prior to mungbean crop after rice) nutsedge growth was induced by flood irrigation once 3 or 4 days for 4 weeks whereas the other two applications (prior to mungbean crop before rice and rice crop respectively) mainly depended on rainfall. The herbicides were applied by powered knapsack sprayer with 3 T-jet nozzles spraying a swath 1.5 m wide under the pressure of 30 psi. With the spray volume of 400 l/ha. Usually cultivation was made about a week after application of herbicides. Mungbean, var M7A was planted in rows 50 cm apart. Rice seedlings, var. Lueang-on, about 30 days old were transplanted after harvesting of mungbean crop before rice. Initially direct seeding was planned,but the frequent rainfall changed the planting method to transplanting.

RESULTS AND DISCUSSIONS

The results (Table 1.) showed that glyphosate at 0.8 and 1.6 kg/ha applied alone and the application of glyphosate with ammonium sulfate significantly reduced nutsedge population. There was no difference between low and high rate neither with nor without ammonium sulfate combination. This is probable even at low rate: was adequate to give maximum control of this type of nutsedge which tubers thrive inactive in the water for a period of time (up to 5 month) as well as in the soil. The reduction was ranged up to 90 % of control (column 2). Unfortunately repeat application of glyphosate did not yield complete control, but the stands were substantially reduced (column 4,5 and 6).

It is also noted that nutsedge stands in each application varied to some extent. The stands in first and third applications (column 2,3 and 6) were less than in second application (column 4 and 5). This is possibly due to the observation (stand count) made during dry period of the year, which generally the plant is not inactive stage. This is in contrary to second application which was conducted in early rainy season.

Glyphosate did not cause injury or yield reduction of mungbean and rice (column 7,8) at low and high rate, and with ammonium sulfate combination. At the same time the chemical treatments produced higher yield of mungbean 35-40 % over the non weeded control. Because of high density of nutsedge population practically, hoe weeded control was just the same effect as unweeded plot. Our usult clearly indicate the lower plant density of nutsedge in glyphosate treated plots. Unfortunately, the mungbean yield in first application was not available due to heavy infestation of bean flies at early stage which caused damage and failure to the crop.

Grain yield of transplanted rice was neither affected by glyphosate nor its combination with ammonium sulfate. It was not affected by high population of nutsedge in the nonweeded control either. This is due to the fact that after land preparation was done the soil surface was under water level for about 4 months until crop was ready for harvest. In this situation, the tubers in the soil were unable to sprout. Practically because of ununiform levelling, especially in the period of low water level,some tubers germinated. This possibly could be the reason why non-weeded control yielded slightly less than weed control which some nutsedge plants were removed 30 days after transplanting

In a separate experiment conducted by us (Table 2), in the Department of Agronomy Greenhouse in 1978, the following conclusion can be drawn as followed:

1. Nutsedge is weak when its base is submerged under water and unlikely to sprout when the water level is high enough.
2. To control nutsedge in rice field, 2,4-D at the rate of 1.5 kg/ha (240 g. a.i. per rai) is enough to stop nutsedge growth all through the season so far as water level is kept high all the time.
3. In mungbean, or other crops, glyphosate 0.8 kg./ha (128 g.a.i. per rai) can be used. Nutsedge control will last at least two successive croppings. However, the cost of the chemical is relatively high (120 baht/rai per single application). Even 60 baht/rai per single application is considued costly for mungbean Unfortunately, using 2,4-D to control nutsedge in mungbean is not possible due to the fact that this chemical give lethal effect to mungbean.

SUMMARY

In the one year experiment, it was found that two successive preplant application of glyphosate on purple nutsedge in mungbean plus one other application of this particular herbicide in transplanted rice significantly reduced nutsedge population, however, a conplete control could not be achieved. Glyphosate at low rate (0.8 kg/ha) was enough to obtain good control of nutsedge. Effect of this chemical on mungbean and rice was neither visually detectable nor caused the yield reduction. High population of nutsedge substantially reduced yield of mungbean but not of transplanted rice

Table 1. Effect of repeat preplant application of glyphosate on purple nutsedge population in mungbean rice sequential cropping.

Herbicide (glyphosate) (kg/ha)	Plantdensity, stands per 50 x 50 cm^2 quadrat 1/						Crop yield as % of control	
	(1) Intitial Stand	(2) Wk.after 1st application 2/ 4	(3) 7	(4) Wk.after 2nd application 4	(5) 10	(6) no.after 2nd application	(7) Mungbean (2nd crop)	(8) Rice
0.8	64.12 a	1.31 b	2.11 b	8.15 b	9.44 b	2.75 b	137.12 a	112.89 a
1.6	76.12 a	0.72 b	2.53 b	6.35 b	7.20 b	2.43 b	141.04 a	118.01 a
o.8+amm.Sulfate 10	82.25 a	2.15 b	2.92 b	4.40 b	8.85 b	8.60 ab	137.69 a	94.05 a
1.6+amm.Sulfate 10	79.00 a	1.23 b	1.96 b	6.30 b	7.90 b	3.50 b	142.31 a	94.00 a
Control-Weeded 3/	83.37 a	22.20 a	24.30 a	23.16 a	28.52 a	15.98 a	100.00 b (2,252g 4/)	100.00 a (737g)
Control-nonweeded	68.50 a	20.34 a	27.56 a	24.65 a	25.22 a	16.40 a	94.70 b	86.00 a

1. Means within the column followed by the same letter are not significantly different at 5 % level using Duncan's multiple range test.

2. 1st, 2nd and 3rd application of herbicides made on Feb 15, May 15 and July 25, 1978. Mungbean planted 1 week after 1st, and 2nd application. Unfortunately the first planting failed and yield was not available. Rice was transplanted 3 weeks after third application of glypaosate.

3. Hoe-weeding of nutsedge practically did not work in mungbean planting, but slightly effective with hand weeding in transplanted rice.

4. Mungbean seed yield per 4 x 2 m^2 and rice grain yield per 2 x 2 m^2.

Table 2. Effect of Glyphosate with and without Ammonium Sulfate Combination on Purple Nutsedge in lowland and upland condition. Fresh weight of regrowth of nutsedge as percentage of control

Herbicide(kg/ha)	Upland condition	Lowland condition (basal bulbs 1.5 c.m. under water)
Control - nontreated	(4.33 g) 100.00a	(1.29 g) 100.00a
Glyphosate 0.25	41.3 b	35.7 b
Glyphosate 0.50	21.2 bc	0 c
Glyphosate 1.00	0 c	0 c
Glyphosate 1.50	0 c	0 c
Glyphosate 0.25 +amm.Sulfate 10	2.8 c	0 c
Glyphosate 0.50 +amm.Sulfate 10	0 c	0 c
Glyphosate 1.00 +amm.Sulfate 10	0 c	0 c
Glyphosate 1.50 +amm.Sulfate 10	0 c	0 c
2,4-D 1.5	1.8 c	0 c

Means within the column followed by the same letter are not significantly different at 5 % level using Duncan multiple range test.

Note.		
	Tuber germinated	Feb 17, 1978
	Planted in pots	Feb 27, 1978
	Sprayed	March 10, 1978
	Removal of shoot	March 17, 1978
	Regrowth weight	April 12, 1978

4 tubers/ pot . 4 pots /treatment

PURPLE NUTSEDGE CONTROL WITH FOUATH APPLICATION OF GLYPHOSATE IN MUNGBEAN GROWN AFTER RICE

BY

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PURPLE NUTSEDGE CONTROL WITH FOURTH APPLICATION OF GLYPHOSATE IN MUNGBEAN GROWN ARTER RICE

INTRODUCTION

Purple nutsedge (*Cyperus rotundus*),a serious weed problem around the world, can be found almost every cultivated land in Thailand. Cultivativation or preemergence herbicide application were unable to control purple nutsedge successfully. Glyphosate, a postemergence herbicide with leave no residue in s soil, provided a great control of purple nutsedge. The application of glyphosate as preplanting before mungbean and rice crops may reduce purple nutsedge infestation.

The objective of this experiment were to study the purple nutsedge population after the application of glyphosate four times in the same area and investigate the effect of glyphosate and other pre emergence herbicides to mungbean yield.

MATERIALS AND METHODS

Preplanting application of glyphosate for controlling purple nutsedge plus pre-emergence application of some other herbicides had been given to the plot planted to mungbean at Bangphae district, Rachaburi province, from February to April 1979. This was the gourth application of glyphosate in this particular area. The first, second and third application of herbicides were made on February 15, May 15 and July 25 1978. Mungbean was planted, week after 1st and 2nd application. The first mungbean planting was attack severly by bean flies (*Ophiomyia sp*,)and yield was not available Rice was trans planted 3 weeks after tird application of glyphosate. Treatments were replicated four time in a split polt design. Glyphosate as a mainplot was applied one week before mungbean was planted, at the rate of 0.8 and 1.6 kg/ha with and without ammonium sulfate fertilizer. Subplot were linuron

1.0 kg/ha, metalachlor 2.0 kg/ha, thiocarbamate 2.0 kg/ha + linuron 0.5 kg/ha and oxadiazon 0.75 kg/ha applied as pre-emergence. Subplot was 4 x 4 m^2 in size and 4 rows with 0.5 m. row width. All herbicide treatments were applied by Knappsack sprayer at 400 l. per ha. with T-jet No. HSS 8003. Soil is clay with 2.5 % organic matter. Fertilizer 14-14-14, at the rate of 25 kg/ha was applied before planting. Land was irrigated as needed.

Mungbean were harvested and weighed, 30 plants per plot and number of nutsedge shoots were counted 40 days after planting.

RESULTS AND DISCUSSION

Purple nutsedge control with glyphosate has been done in permanent purple nutsedge control program by the application of glyphosate four times in the same area, crops were planted after each glyphosate application. First and second glyphosate application has been done before mungbean was planted before rice in 1978. After first crop of mungbean was harvested, third glyphosate application was applied before rice was planted in August 1978. After rice was harvested in December, glyphosate 1.6 kg/ha with or without ammonium sulfate 10 kg/ha did reduce purple nutsedge population (Table 1). After land was irrigated the population of nutsedge plant was increased only in the control plot. However, in glyphosate treatments, nutsedge population was slightly low. This fourth glyphosate application has been done in order to give a complete yellow nutsedge control befor mungbean was planted after rice. Glyphosate 0.8 and 1.6 kg/ha without ammonium sulfate also reduce the population of purple nutsedge (Table 1) similar to application of this herbicide with ammonium sulfate. Since glyphosate is a translocated herbicide, absorbed by leaves, therefore, it may be able to translocate from leaves to tubers of nutsedge easily and kill those tubers. Although the population of nutsedge plants was decreased tremendously in herbicide treated plots compared to the control one, a complete control of nutsedge did not achieve as indicated by small number of nutsedge remain in those herbicide treated plots. The tendency of this weed to resist to glyphosate herbicide can be explained by its dormancy period. The plants that sprouted before herbicide application absorb the chemical considerably and could be killed. However, plants that sprouted after preplanted herbicide application remaining in the plot, propagated and could infested the next crop.

Control-non weeded in the main plot has a potential to cause mungbean fresh weight reduction (Table 2). However, significant different could not be obtained because the population of nutsedge plants was low when planting started (Table 1).

Control non weeded in subplot did not showed any significant different for reducing mungbean fresh weight when compared with other herbicide treatments (Table 3) because no annual weeds germinated at that time. The only weed problem for mungbean after rice was the volunteer rice which infested mungbean strongly. After harvesting rice,some grain were remained on the ground and did not germinated due to dryness. However, when irrigation was given, rice were germinated and no pre-emergence herbicide that applied for mungbean in this experiment could control volunteer rice excepted metalachlor. Linuron, metalachlor, thiocarbamate + linuron and oxadiazon did not reduced mungbean fresh weight (Table 2). However, only oxadiazon as subplot in glyphosate 1.6 kg/ha + ammonium sulfate as mainplot reduced plant fresh weight.

Table 1. Number of purple nutsedge plants per 0.25 m^2 before and after glyphosate application (mainplot).

Herbicides	Rate kg/ha	Plants/.25 m^2	
		before planting	after planting
glyphosate	0.8		
+ ammonium sulfate	10.0	2.75	7.3
glyphosate	1.6		
+ ammonium sulfate	10.0	2.43	2.3
glyphosate	0.8	8.6	14.3
glyphosate	1.6	3.5	4.8
control non weeded		16.4	56.5
	L.S.D. ,05	9.68	23.5
	L.S.D. .01		32.5
	C.V.	72.%	77 %

Table 2. Freshweight of mungbean after preplanting application of glyphosate and pre-emergence application of some herbicide, 40 days after planting.

Mainplot	Fresh weight g/30 plants/plot
1. Glyphosate 0.8 kg/ha + Ammonium Sulfate 10 kg/ha	136.37
2. Glyphosate 1.6 kg/ha + Ammonium Sulfate 10 kg/ha	159.37
3. Glyphosate 0.8 kg/ha	148.92
4. Glyphosate 1.6 kg/ha	152.43
5. Control non-weeded	108.57
	N.S
	C.V. 69.31 %
Sub plot	
1. Linuron 1 Kg/ha	149.29
2. Metolachlor 2 kg/ha	135.16
3. Thiobencarb 2 kg/ha + Linuron 0.5 kg/ha	166.42
4. Oxadiazon 0.75 kg/ha	134.71
5. Control non weeded weeded	115.73
	N.S

Table 3. Fresh weight of mungbean after preplanting application of ghyphosate and preemergence application of some herbicide, 40 days after planting

Mainplot	Subplot: Linuron 1.0kg/ha	Metolachlor 2.0kg/ha	Thiobencarb 2 kg/ha+ Linuron 0.5 kg/ha	Oxadiazon 0.75 kg/ha	Control non weeded	L.S.D. compare within subplot of the same glyphosate level
Glyphosate 0.8kg/ha + Ammonium Sulfate 10 kg/ha	167.5	.37.5	143.75	123.75	121.25	NS
Glyphosate 1.6kg/ha +Ammonium Sulfate 10 kg/ha	190.0	130.0	185.00	110.00	157.5	NS
Glyphosate 0.8kg/ha	230.0	122.5	141.25	146.25	98.75	NS
Glyphosate 1.6 kg/ha	150.0	156.25	157.1	155.00	146.25	NS
Control non weeded	75.75	132.22	114.96	120.7	66.85	NS

L.S.D. Compare within subplot at the same or difference glyphosate level = 70.21

C.V. 23.42 %

THE EFFECT OF PRE EMERGENCE HERBICIDE IN WEED NUMBER AND YIELD OF MUNGBEAN WHEN GROWN BY ROW PLANTING AND BROADCASTING METHODS

BY

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THE EFFECT OF PRE EMERGENCE HERBICIDE IN WEED NUMBER AND YIELD OF MUNGBEAN WHEN GROWN BY ROW PLANTING AND BROADCASTING METHODS

INTRODUCTION

Weed competition is a major problem in mungbean production when planted before rice crop in Central Thailand. Rainfall which started early May enhanced weed growth and its competition to mungbean production tremendously in Bangpae district, 100 kgm. south of Bangkok (3). The yield loss of mungbean up to 95 percent was obtained in rainny season in the Philippines and up to 60 percent in spring in Taiwan (1,2). Howerver, in the dry season, competition from weed was considerably minimal.

Controlling weed in mungbean fields was found difficult since farmers generally broadcast their seeds rather than planted mungbean in rows. Uneven density of plants caused by broadcasting inhibited farmers to weed and cultivate their crops. Row planting mungbean appears to be advantageous over broadcasting due to several reasons; firstly, plants received more uniform spacing which will allow tham to express their yield potential bether, hence, higher yield will be obtained. Secondly, weeding mungbeans which is planted in rows can be done easily by farmers. The main reason why farmers are probably unwilling to plant mungbean in rows instead of broad casting is due to the fact that they would not like to increase their economic resource in weeding and planting mungbean in rows considering different in yield of row planting over broadcasting has not been established yet. The use of pre-emergence herbicide in row planting mungbean may offer lesser input for farmers comparing to labor cost in weeding.

This experiment was conducted inorder to study the effect of pre - emergence herbicide in controlling weeds of mungbean grown by broadcasting and row planting in farmer's field.

MATERIALS AND METHODS

A split-split plot experiment replicated three times was conducted in the farmer's field at Bangpae district on May 18, 1978. Main plots consisted of two fertilizer treatments, F_1 and F_o,F_1 was a fertilizer given plot in the form of 16-20-0 mixed fertilizer applied at the amount of 312.5 kg/ha before mungbean planting while F_0 plot received no fertilizer. The sub plots consisted of two methods of planting, broadcasting versus row planting mungbean. Broadcasting was done by ploughing followed ty broadcasting seeds followed by harrowing. Row planting mungbean was done by single ploughing followed by harrowing followed by making rows.5 m. apart and seeds were drilled in rows. The seeding rate for broadcasting and row planting were 25 kg/ha. Two sub-sub plot consisted of pre-emergence application versus none. In the plot received pre-emergence herbicide, Alachlor (Lasso 43.3% EC) at the rate of 2.15 kg.a.i./ha was applied immediately after planting. No irrigation was given to this field,M7A mungbean was used in this experiment. All plots were harvested on July 20,1978.

RESULTS AND DISCUSSION

The field planted to mungbean during this period before rice crop was infested to weeds which grew rapidly due to rainfall which occur in early May. Up to seven species of weeds were found in almost every mungbean plots in this particular season. The most predominant weed species found in mungbean plots was listed in Table I.

Table I Predominant weed species generally found in mungbean field planted before rice in 1978

I	Echinochloa	colonum
II	Cynodon	dactylon
III	Ischeamum	rugosum
IV	Ipomaea	aquatica
V	Commelina	bengalensis
VI	Cleome	viscosa
VII	Euphorbia	hirta

In this experiment, there was no different in number of weeds/sq.m between fertilizer applied plots. Neither broadcasting nor row planting mungbean gave any significant different in weeds number. Only herbicide applied treatments reduce weeds number tremendously when compared to no - herbicide given plot.

In this experiment, there was no significant difference in number of weeds per square meter between fertilizer applied plots. Neither broadcast nor row planting mungbean gave any significant difference in weed number. Only herbicide treatment reduced weed number significatly when compared to nO-herbicide treatment ($P < 0.05$). The average number of weed in herbicide plot(L_1) was 87.5 while in no-herbicide plot(L_0) was 164.2 (Table 2).

Table 2. Number of weeds per square meter in Fertilizer x Method of Planting x Herbicide experiment.

	Fertilizer given		No fertilizer given		Means
	Row Planting	Broadcasting	Row Planting	Broadcasting	
Herbicide(L_1)	88	114	82	66	87.5
No herbicide (L_0)	180	155	166	156	164.2
Means	178.0	134.5	124.0	111.0	

Among seven pre dominant weeds shown in Table 1. Echinochloa colonum were counted as the major contribution to weed density in mungbean field in 20 out of 24 plots. Up to 68 plants of Echinochloa colonum among 100 plants of weeds were found when counted weed density. Only 4 among 24 plots had Cleome viscosa as their major weed having density contribution between 36-68 percent.

The yield of mungbean were found significantly higher in row planting than broadcasting. Regardless of fertilizer application, the yield of mungbean was 86.69 kg/ha higher when planted in rows compared to broadcasting ($P < 0.01$). The yield of mungbean were slightly higher when received fertilizer when compared to non fertilizer plot although the difference were not reached significantl leved. The yield of mungbean received fertilizer was 383.19 kg/ha while the yield in plot received no fertilizer was 330.94 kg/ha. Similarly, the yield of mungbean was also slightly higher in the plot received pre-emergence herbicide when compared to no herbicide plot, although significant level was not reached (Table 4).

Table 3. Yield of mungbean (kg/ha) when planted in rows and broadcasting methods with and without fertilizer application.

	No fertilizer given	Fertilizer given	Means
Row planting	363.62	437.31	400.31
Broadcasting	298.19	329.06	313.62
Means	330.94	383.19	356.96

Table 4. Yield of mungbean(kg/ha) when planted in rows and broadcasting methods with and with out the application of pre-emergence herbicide.

	Row planting	Broadcasting	Means
Herbicide Given	423.36	336.12	379.74
No herbicide Given	377.63	291.14	334.39
Means	400.50	313.63	357.06

The result of this experiment demonstrated that, the use of Alachlor as pre-emergence herbicide would effectively control weeds in mungbean ad result into lesser input and labor cost in weeding. However, the yield of mungbean was not primarily affected by weed. Consequently, better and more uniform spacing as provided by row planting mungbean would allow the plants to express their yield potential much better than planting mungbean by broadcasting. Therefore row planting would give better yield in mungbean than broadcasting particularly in the growing season before rice crop. In term of weed control practice it would be easier to weed mungbean in rows rather than weed broadcasting mungbean. Therefore, during the period inwhich mungbean can be grown before rice crop, planting mungbean in rows plus using pre-emergence herbicide would provide mungbean crop with better spacing and weed control, therefore, high yield can be obtained.

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THE ROLE OF PEST MANAGEMENT ON MUNGBEAN IN MULTIPLE CROPPING SYSTEM

BY

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THE ROLE OF PEST MANAGEMENT ON MUNGBEAN IN MULTIPLE CROPPING SYSTEM

INTRODUCTION

In evaluation prospects for increasing or improving world food output, emphasis is traditionally placed on two dimensions: (1) expanding area, and (2) improving yield of individual crops. Peculiarly, little has been said about a third possible dimension:time. It is possible to make fuller use of time by multiple cropping the practic of growing more than one crop on the same piece of land in a year. Multiple cropping makes possible both on increase in area cultivated per year as well as on increase in total yield per unit of area per year. In Thailand, the KU-IDRC multiple cropping project has been started in 1973. This project is a research program of Kasetsart University financed by International Development Research Center (IDRC) Canada. The final goal to provide farmers with simple recipes and predictions of effects of adopted measures.

During the first few years researches were only conducted at Kampang-saen Student Training Center 90 kilometers south of Bangkok and the surrounding villages. It has been over two years since the Multiple Cropping Research Project had moved its only research activities to the farmers' fields at Bangpae District, Ratchaburi Province. The project encountered several problems in conduction experiments under farmers' condition during its first year (1977-1978) at Bangpae.

THE NEED FOR PEST MANAGEMENT PROGRAM

At the beginning, the Department of Agronomy and the Department of Agricultural Economic have conducted researches and base-line study to find out the best and most suitiable cropping system. Nevertheless, the need for improved collaborative action between the various disciplines involved in crop production, processing, storage, and marketing in view of production optimization has been repeatedly stressed in recommendation issued by plant protection conferences. However, little seems to have been implimented by individual countries along these lines except perhaps in places where pest management system are operational.

It appears that in many countries there is little contact between crop protection specialists and agronomists, the latter being still of the opinion that protecting crop with pesticides is cheap and easy. Although the research programs are directed by multidisciplinary teams of scientists including plant breeders, soil scientists, agronomists, weed scientists, entomologists, pathologists and other, these latter two disciplins were not sufficiently covered in the initial stage, which brought about the already mentioned difficulties.

The role of entomology within intigrated program of multiple cropping systems at Bangpae was started in early 1979. We are planning to work on mungbean, soybean, rice and sweet corn respectively by using pest management system. The practice of pest management is essential to the future and accordingly deserves to priority. It is part of applied ecology, relying heavily on the significance of pest and natural enermy population densities in terms of threshold values. We try to expess our program at Bangpae by using mungbean as a model for other crops.

PEST MANAGEMENT SYSTEM IN MUNGBEAN

The systems approach to the management of mungbean insects in Thailand is not available yet. Before 1979, the life cycle and chemical control on the mungbean insect pests was studied with occasional damage. Because of the lack of ecological aspect of insect pests and crop, chemical control was the basis of most recommended systems from the original growth of mungbean up to the late 1978's. This general review of controlling insect control relied to a large extent on the wider spread, seasoning use of synthetic organic insecticides. Fortunately recent studies in Thailand on pest management have been made in the refinement and improvement of the earlier system.

As entomologists, we saw a need to increase the rate of adoption of insect pest management . We asked ourselves why weren't farmers accepting even the most basic principle such as the most advantageous planting periods, the use of plant resistance to insect, through destruction of post harvest crop residues, etc? After much time spent analyzing this enigma, we came to the conclusion that we were greatly oversimplifying the problem.

On our program with pest management, we will attempt to show by way of explanation how one might implement on insect pest management program on mungbean Starting in 1979, by virtue of an KU-IDRC grant, the entomologists received funding for implementation of a pest management program.

The entomologists from Department of Entomology, Kasetsart University resides in the area year around and has responsibilities for training research assistant to inspect mungbean in the farmer's field a weekly or bi-weekly basis for the occurrence of pest species and damage, the incidence of beneficial insects, the stage of mungbean growth, etc. The result will provide basic entomological informations plus economic threshold levels for each key pests.

ECONOMIC THRESHOLD

In any pest management approach the knowledge of economic threshold for individual pests is prereguiste, It is roughly, the value of the loss expressed in monetary terms occuring from the insect organism which is in balance with the costs resulting from action taken to prevent this loss. Therefore, the following values have to be determined:

1. Quantity of insects-causing damage (e.g. population density)
2. Relation between quantity of the insect and the extent of monetary losses.
3. Costs inherent in preventing the damage.

The economic threshold may thus be changing from one year to another especially in consideration of the variability of the commodity prices. It clearly reflects the cornerstone of any crop protection action and also includes necessarily ecologiceal considerations. Without threshold values, crop protection remains guesswork. Even temporary and rough evaluations of these values may considerably change the protection pattern.

At the beginning of our entomological research at Bangpae, we collected all of the insects found on the mungbean, then separated them into 4 groups namely:

1. Insect pests.
2. Potential insect pests
3. Insects that found on the mungbean but do nothing or do little harm to the crop.
4. Beneficial insects.

The method which we use are sweep net and collect whole plant sample at random weekly. The number of insects and damage are counted and recorded. According to our initial survey using the above mentioned procedure we found that there are 3 insects pests on mungbean at Bangpae as followed.

1. Bean thrips Taeniothrips longistylus Karny (Thysanoptera:Thripidae)
2. Flea beetle Longitasus manilensis Weise (Coleoptera:Chrysomelidae)
3. Red spider mite (not identified yet)

The thrips, on dry season pest, attacts the young plant and can be managed by careful field inspection and precise timing of insecticide applications when economic thesholds are passed. Every effort is made to keep early season insecticide applications to a minimum in order to preserve populations of parasites and predators which help to suppress mungbean insect pests populations. The damage caused by thrips differs greately depending on the developmental stage of mungbean plants. Damage on young plant induces entire dwarfing of mungbean plant, resulting in a total loss of mungbean yield.

The second steps, we do need some ecological informations as same as on bean thrips for the flea beetle and red spider mite. We also need to find out the volue of economic threshold for bean thrips, flea beetle and red spider mite. The result of economic threshold will be used as a criteria for making the spraying decision for spray or not spray.

The third steps, we approach sampling technique to determine the insect pests population in the farmers' fields by weekly interval. This step will be done at the same time as the research on economic threshold. If the number of insect pests or damaged are reached the economic thredhold, we will make the decision to spray or not. The main reason of this step is to decrease the high frequent usage of insecticides.

On the fourth step we will try to found out the effectivenen of economic threshold on each pest by comparing it with other treatments e.g.

a) Control (do not spray any insecticides).

b) Spray insecticides every week.

c) Spray insecticides at critical stage of plant growth

d) Spray when necessary by using economic threshold and sampling technique.

If our program are working out good as we expected, we will try to samplily the insect pest management system and extend then to the farmers. It is also necessary to have a training program, for the farmers at this step.

On the fifth step we try to include biological control into the total program of insect pest management. At this step we will measure the effectiveness of predators, parasit and pathogen of an insect pests by comparing with the population dynamic of both beneficial insects and insect pests.

On the sixth step which will be started on early 1980, we will include all other methods of control from the previous lituratures with our research informations into total pest management program. Then the effectiveness of pest management program will be tested in the field on superimpase levels. In this case the pest means insects, weed and disease.

On the seventh step which will be started on early 1981, the program will be recorrected. The pest management program may be improved by adding some others techniques and our experience or some other available methods of control into the total program. This inproved program will be tested again in the super-impose field.

EMPHASIS ON THE ROLE OF PESTICIDES

As mentioned in the first approach of KU-IDRC multiple Cropping project, farmers in Bangpae, Ratchaburi area try to protect their crop loss, especially mungbean, by pesticide spraying. By this mean, it seems to be easier and preferable for them in accordance with an availability of number of pesticides introduced by commercial pesticide producers. It is, however, essential to achieve the proper use of pesticides as the effective tool in the pest management program. The strategy of this subject should be comprehensively discussed.

One must be born in mind that pesticides are highly effective and positive for the control of pest outbreaks. Actually, when pests populations reach economically damaging levels, there is a little other than pesticides which can be practiced to avoid damage. Therefore, it is expected that pesticides will continue to be an important tool in pest management. The strategy of pest control may, in some special cases, conduct successfully, without any connection with pesticide but the over all reviews of crop protection record indicate that most of the agricultural and public health areas pesticides played a role for increasing the crop production. However, in years, scientists and general public are in broad general agreement that serious disadvantages are associated with the use of pesticides. This is particularly true for the pattern of pesticides use which evolved in the past two decades. Problems occurred are mostly related to the indiscriminate and almost vliance upon pesticides used in a pest prevention and control scheme. This includes the results in development of insecticide resistant strains, out-break of the secondary pests, disruption of the ecosystem which induced the failure of balance of nature, pesticide residue on the harvested crop and other human hazards and general contamination of the environment as well.

There is evidence at present of an ever increasing trend toward an era of pest management which utilize the combination of pest control methods and particularly, away from excessive use of pesticides. Government agencies, researchers, grower organications and chemical industry are working at the need to make changes in pest management strategy and the role of pesticides in this integrated approach. This program should be initiated at Bangpae, Ratchaburi province.

As mentioned above, to assist pest managers in making better choices of pesticides, careful consideration should be made on their suitability for use in pest management program regards to their safety and effects on environmental quality. Fortunately, a vast array of chemical control agents are available, it is possible to quickly choose a pesticide or pesticide combination which will control effectively almost any pest situation. The selection an effective pesticide and proper use for the control of key pests is essentially needed for pesticides use in pest management system. The strategy of this proper selecting pesticide from available candidateds, the pest manager must consider

1) efficacy on the target pest,
2) mammalian toxicity,
3) effects on nontarget organisms including pollenators, parasites, predators and wildlife, and
4) fate in soil, water, air and in the commodity.

Pesticides use in a pest management system may be divided into three general catagories as follows:

1. Carefully timed applications directed at a strategic or weak point in the pest's life cycle and designed to exert a suppressive effect upon subsequent population build up. altunative methods should be born in mind and their compatibility with pesticides application. Natural or cultural practices, in some cases, will provide better measure to suppress the pest population remained by the destruction diapause stage of pests. This allows more effective used of natural control facters for secondary pests occurrence during the following season and reduces the amount of pesticide used.

2. Selective treatment for effective control may be made with a mininal quantity of pesticide during the growing season to provide suppression pressure upon a developing potential pest problems and causes the least possible chance of disrupting natural control forces. An example of this is the use of seed treatments, spot treatment of localized infestations of pests during the early season period. Maximum use should be made in such cases of pesticide with some degrees of selectivity for the target pest if available.

3. Inseason chemical treatment should be made when economic threshold levels of pests are exceeded despite all other pest suppression methods. While alternate nonchemical pest control methods.may be preferred, it is inevitable that under present agricultural practice, economically damaging pest populations will occur and a positive control methods for

this situation is strongly needed. At present, pesticides are the best resource to use in such cases. It is imperative that usage should be compatible with the pest management scheme. They should be used only when needed, based on pest population assessment and carefully selected for both efficacy against the pest and the potential for causing disruption in ecosystem. Ideally, the solution to the problem concerning with the use of pesticides would be considered to develop alternate non-chemical control methods for use and strengthening how to achieve on the proper pse of pesticides in the pest management practice. There is a general agreement among pest control specialist that pesticides are one of our prominant alternative for pest management and how to use them in such a manner that their advantages are fully realized and their disadvantages are greatly minimized.

Therefore, our willing to extend this knowledge to the farmers at Bangpae for theis understanding and achieve ment the better pest control of their crop loss especislly on mungbean.

EFFECT OF SURFACE MANAGEMENT ON SOIL MOISTURE PROFILE AND WATER USE EFFICIENCY OF MUNGBEAN GROWN AS A ROTATION CROP AFTER RICE

BY

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EFFECTS OF SURFACE MANAGEMENTS ON SOIL MOISTURE PROFILE AND WATER USE EFFICIENCY OF MUNGBEAN GROWN AS A ROTATION CROP AFTER RICE

INTRODUCTION

The method of no tillage was krown to be adaptable on row crop production for number of years. Research works emphasize the adventages of no tillage over conventional tillage are done especially on corn. The method are now widely accepted by farmers in the United States who grow corn and tobacco. The method of no tillage was proved to conserve and to create more availability of soil moisture. Soil moisture conservation is resulted from the rapid intake of applied water or rain through soil surface and by the retardation of surface evaporation. Alternatively and probably the more sounded advantage of the method of no tillage is that it conserves energy that must be otherwise put into the tillage operation. In fact, the no tillage method requires minimum seed bed preparation. Weeds, grass in most cases, were killed by herbicide (usually mixture of paraquat and atrazine) sprayed on the land about a week before seed placement. Seed placement is done in rows and broadcasting of mixed fertilizer is done suecessively without any other alteration of soil surface. Investigators who experianced the no tillage practice found, in several cases, even more production of crops as compared to conventional tillage.

Developing countries under the strain of energy crisis might find the method of no tillage suitable for row crop production.

MATERIALS AND METHOD

Two successive experiments were conducted in rice paddies during the dry season (January to March) of 1978 and 1979. Objectives of the experiments were to investigate on the efficiency of selected surface managements upon conservation of subsoil moisture and the effect of such practices on growth and water use efficiency of mungbean.

There consisted of 3 surface managements in the 1978 experiment, namely; tillage vs no tillage, straw burned vs straw mulched, and mungbean vs weeds. The 1979 experiment consisted of tillage vs no tillage and fertilizer (16-20-0, 16 kg N/rai) vs no fertilizer. The 1978 experiment was done under rain-fed conditions and the 1979 experiment was under irrigated conditions. Experimental design for both experiments was replicated split-split plot for the former and split plot for the latter.

Soil misture sampling on both experiment was done by means of a screw auger. Depth intervals of sampling were 0-10,10-20,20-30,30-40, 40-50,90-100,140-150 cm. from soil surface. Moist soil was wrapped in a tared aluminum foil and soil moisture was obtained in the laboratory gravimetrically. Soil moisture content was expressed in either weight (θw) or volume (θv) basis and were plotted against depth to obtain periodic soil moisture profile. Periodic moisture sampling of the 1978 experiment was a week interval and in the 1979 experiment it was done a day prior to and a day after irrigation throughout the experiment. Weighted average throughout soil profile and that throughout the growing season was calculated by using depth and time as a weighting factor, respectively. Soil water expressed as an equivalent height of water column was calculated by means of area measurement in the 1979 experiment. Formulae used for calculations of weighted average soil moisture content ($\bar{\theta}$), equivalent height of water column (hw), and changes in water content (Δhw) for either evapotranspiration or irrigation water were, respectively (1),(2),and (3) as followed;

$$\bar{\theta} = \frac{\text{area under } \theta(Z) \Big/_0^{150}}{150} \qquad \text{——— (1)}$$

$$hw = \frac{\text{area under } \theta v(Z) \Big/_0^{150}}{100} \qquad \text{——— (2)}$$

$$hw = \frac{\text{area between } \theta_v(Z)\text{'s} \Big/_0^{Z}}{100} \qquad \text{——— (3)}$$

Water gained by irrigation and that lost through evapotranspiration and deep drainage in the 1979 experiment were estimated by graphical interpretations

Yield of mungbean and dry weight accumulation at several stages of growth were observed in the experiments and water use efficiency was calculated for the 1979 experiment.

RESULTS AND DISCUSSION

Some basic physical properties of the soil in the experiment site was presented in table 1. Clay texture was observed throughout the profile with relatively ligh content of silt fraction (19-32% by wt.). Compaction resulted from rice cultivation was observed in the interval 10-30 cm. The overall degree of compection of this soil may be classified as high.. This might associate with appropriate fractions of clayand silt plus poor conditions of aggregations.

Table 1. Some basic physical properties of the soil at the 1979 experiment site. Bang-Pae, Rat-Buri.

Depth	Sand	Silt	Clay	texture	Bulk density	ME	FAP	AWC	Max. H_2O Holding
cm	% by wt.				gm/cm^3	% by vol.			
0-10	2.4	31.8	65.8	clay	1.66	52.8	38.7	14.1	104.8
10-20	3.6	31.7	64.7	clay	1.76	51.6	38.4	13.2	105.9
20-30	4.0	26.8	69.2	clay	1.70	52.4	36.7	15.7	103.1
30-40	5.3	26.4	68.3	clay	1.68	52,9	37,3	15.6	102.7
40-50	4.5	26.8	68.7	clay	1.54	48.8	33.8	15.0	93.5
90-100	5.7	28.0	66.3	clay	1.41	48.2	35.2	13.0	86.8
140-150	0.6	19.3	80.1	clay	1.47	63.3	37.4	25.9	100.9

Table 2. Double weighted average of profile moisture content throughout the growing season and yield of mungbean as affected by surface managements.

	Straw burned		Straw mulched	
	Tillage	no tillage	Tillage	no tillage
$\bar{\bar{\theta}}_w$ (% wt.)	19.0	18.1	17.9	18.5
yield (kg/rai)	43.4	45.7	70.9	109.7

Averages of soil moisture profiles as selected for the moist, partially dry, and dry conditions in attempts to compare surface managements were illustrated in figures 1,2, and3. Moisture profile observed on Feb.2 (obtained an hour after 30 mm.rain) indicated a higher surface infiltration of the no tillage plot as compared to the tillage (fig.1). Lower surface moisture of the no tillage was believed to cause by faster subsurface drainage. The tillage plots lost substantial amount of surface moisture (0-15 cm.depth) during the first month. Surface drying resulted in a self-mulching phenomenon and reduced capillary rise to surface. The effect of self-mulching was evident when conparison between the two practices for subsoil moisture(25-150 cm. depth interval) was taken into account.

Burning rice straw appeared to accelerate moisture loss from the top 25 cm. layer (Fig.2). Relatively dry surface might be caused directly from heat or a hydrophobic layer resulted from burning. Straw burning followed by ploughing seemed to promote subsoil moisture conservation by desiccation of the top 15 to 30 cm. layers. The desiccation of the surface layer, though help conseved subsoil moisture, must be emphasize to be potentially harzardous to shallow rooted or young plants.

Depth of soil moisture extraction by mungbean was confined in the top 50 cm. layers at the end of the first month as revealed from the curves on Mar.9 (Fig.3). The depth extended further as plants developed and reached 95 cm. depth by the end of growing season. Mungbean appeared to be a potentially drought-tolerant, judging by ramification rate of its roots.

Seasonal variation of average moisture content was shown in figures 4,5, and 6 on attempts to compare the effects of surface management. Relatively small differences could be observed between the managements since the rather steady subsoil moisture was taken into account. Averages differences of 0.2, 0.4, and 0.3 percent of profile average was observed for tillage mulching,and vegetation effects,respectively.

A conclusive results of the 1978 experiment were given in table 2. It appeared that a better moisture conservation was obtained by tillage practice in the straw burned plots but vice versa for the straw mulched. In the case of straw burning, tillage operation promoted moisture conservation by desiccating the surface layers that disrupped the continuity of moisture flow to surface. In the case of straw mulched the rice straw offered surface insulation by lengthen flow path of subsurface moisture to the atmosphere and by the way deminished energy available for evaporation at soil surface. Straw burned followed by plowing appeared to be the best moisture conservation method found in this experiment. The method of straw mulched -no tillage was less effective in moisture conservation as compared to the former but offered the best moisture condition at soil surface as revealed by a vicinity of 3-folds difference on yield.

Seasonal average of soil moisture profiles representing the dry side (one day before irrigation) and the wet side (one day after irrigation) as affected by fertilization and tillage practices of the 1979 experiment were illustrated in figures 7 and 8. No marked difference of profile moisture could be observed on different soil fertility. Nevertheless, the evidence seemed to suggest a greater consumption in the fertilization plots, especially moisture extraction from the subsoil.

Consideration paid on the wet end moisture profiles on fiqure 8, it was found that irrigation water wet the top 95 Cm. of the tillage plots more than the no tillage and more soil moisture depletion was found for the latter. In fact, larger portion of moisture being lost from the no tillage plot was due to deep drainage. Substantial amount of loss through evapotranspiration was found on the tillage plots because of larger accumulation of water presented in its surface layers.

Rate of evapotranspiration in Cm./day was plotted against age of mungbean along with irrigation water (Fig 9). Evapotranspiration rate was found not to depend on plant age but rather followed the pattern of fluctuation of the amount of water applied. The dependence of ET on amount of water irrigated was clearly illustrated in figure 10. It might be seen that ET rose steadily with amount of irrigation water to 15 cm. and levelled off beyond that. The steady value of ET was found to be about 12 cm. per irrigation cycle of 24 days. Therefore, an estimated potential evapotranspiration was around 0.5 cm. per day for mungbean in this experiment.

The deep drainage, likewise, depended primarily on an amount of irrigation water (Fig. 11). Accelerated loss of soil water due to deep drainage was found to comment beyond 15 cm. of irrigation water. Deep drainage rose at about 1:1 beyond that limit.

It appeared from this experiment that an amount of 15 cm. irrigation water was optimum for field irrigation in the period of 3 weeks and in the average case of existing soil moisture.

Characteristics of dry weight accumulation of mungbean grown under different surface management were illustrated in figure 12. It might be observed that the accumulation curves for tillage and no tillage plots followed a different trend. The no tillage plots showed a greater rate of accumulation in the log-stage as compared to the tillage. Response of dry weight accumulation to soil fertility level was also found less pronounced for the no tillage plots. The drop on no tillage-no fertilizer at 57 days of age was due accidently to stem rot disease. An average rates of dry matter production were found to be 3.75 kg/rai -day for the no tillage plots and that for the tillage was only 2.65 kg/rai-day.

Close relationship between dry weight accumulation and accumulative evapotranspiration was established (Fig. 13). Pronounced dry weight accumulation began after 14 cm. water was consumed. Beyond 14 cm. H_2O the more water used resulted in the more plant dry weight accumulation. Since more evapotranspiration was found in the tillage plots as compared to the no tillage while the latter produced more dry weight, it was quite reasonable to assume that flow of water out of the soil in the process of evapotranspiration occured more through plant roots grown under the no tillage conditions. This phenomenon might arise from the fact that subsurface drainage was less in the tillage plots and the applied water was exposed more to evaporative demands.

An integrated informations concerning the efficiency of water use as a result of surface managements of the 1979 experiment was given in table 3. Values were averaged over 2 replications. It was clearly noticed that the efficiency of water use (plant dry weight per unit water consumed) was higher for the no tillage plots at every stage of growth. Smaller ratio of ET/IRR was found for the no tillage plot as for the tillage on a comparable amount of irrigation water and the no tillage plots had a tendency to have higher water loss through deep drainage. The results confirmed the fact that the no tillage conditions allowed faster subsurface flow of water and resulted in the more availability out of an amount presented. Loss through deep drainage might be easily controlled by limiting the amount of irrigation water not to exceed an amount the profile could hold.

Table 3. The efficiency of water use as affected by surface managements.

Treatment	IRR Total (cm)	ET Total (cm)	ET/IRR	DD Total (cm)	DD/IRR	Water use efficiency at the age of (days) 32	39 (kg/rai cm.)	47	57
NO FERT									
No TILL.	40.1	25.7	0.64	20.9	0.52	4.0	5.7	15.6	12.7
TILL.	29.2	25.4	0.87	9.0	0.31	2.6	2.6	6.3	8.7
FERT.									
No TILL.	32.8	24.1	0.73	12.1	0.37	4.5	6.4	11.3	16.4
TILL.	41.8	29.4	0.70	19.1	0.45	3.0	5.6	8.6	11.6

IRR = Irrigation water

ET = Evapotranspiration

DD = Deep drainage

$$\text{Water use efficiency} = \frac{\text{Mungbean dry weight}}{\text{(unit area)(ET)}}$$

CONCLUSION

Upon an attempt to investigate the efficiency of profile moisture conservation after harvesting rice, rice straw burning followed immedieately by ploughing was found very effective but, unfortunately, the practice was found to expel too much of the surface moisture at a degree harzardous to mungbean roots. The method of straw mulched-no tillage was found to accelerate to a certain degree on moisture depletion but provided a favorable moisture conditions at soil surface by capillary rise. Suitable surface moisture was of critical importance for mungbean as revealed by the large difference on yield. The conditions of no tillage was also found beneficial in irrigated plots. Higher dry weight accumulation as well as water use efficiency were found for the no tillage plots as compared to that of the tillage plots.

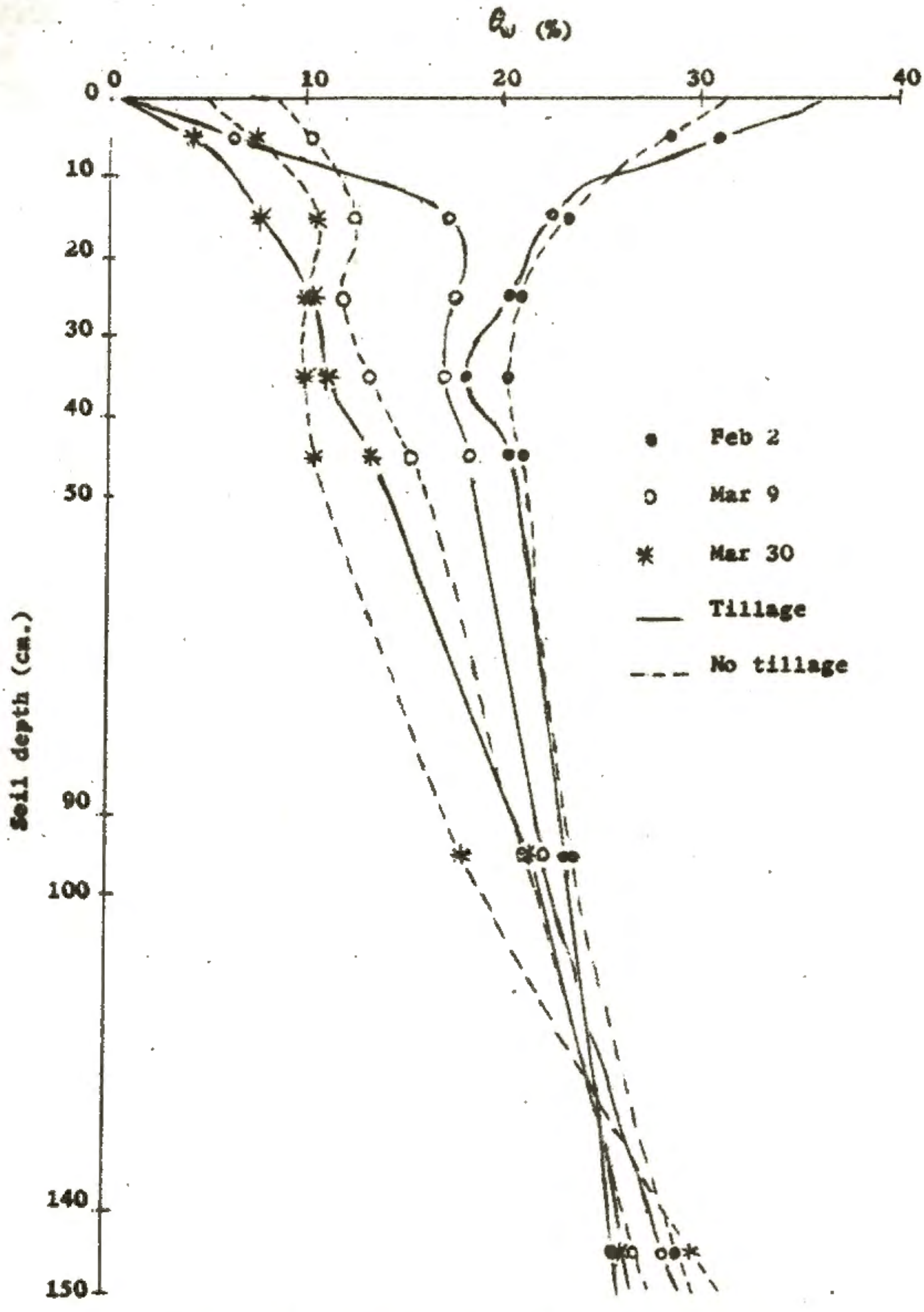
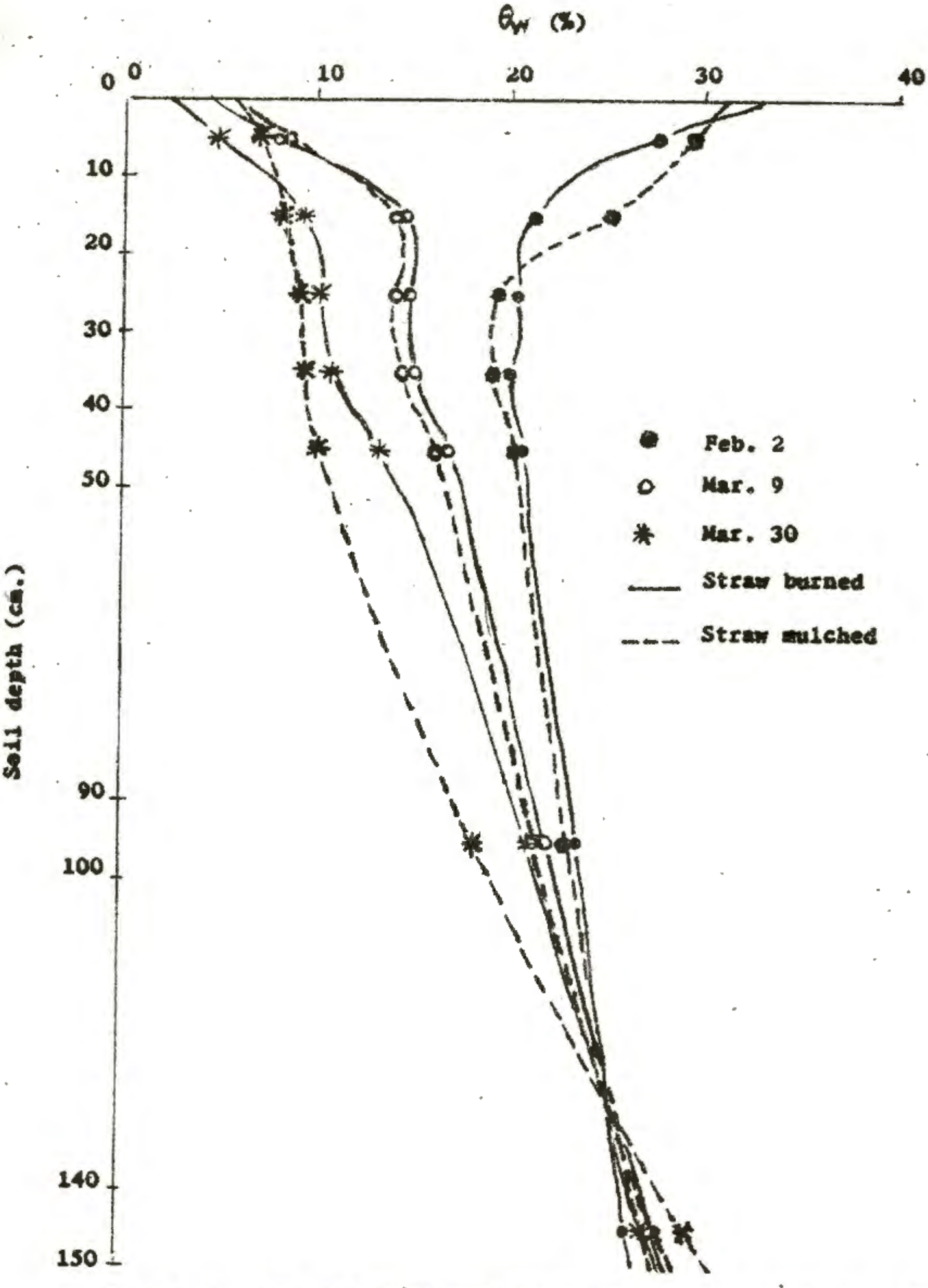


Figure 1. The effect of tillage practice on soil moisture profile as selected for 3 dates of observation. Each data point replicated 4 times.



Fegure 2. The effect of surface mulch on soil moisture profile as selected for 3 dates of observation. Each data point replicated 4 times.

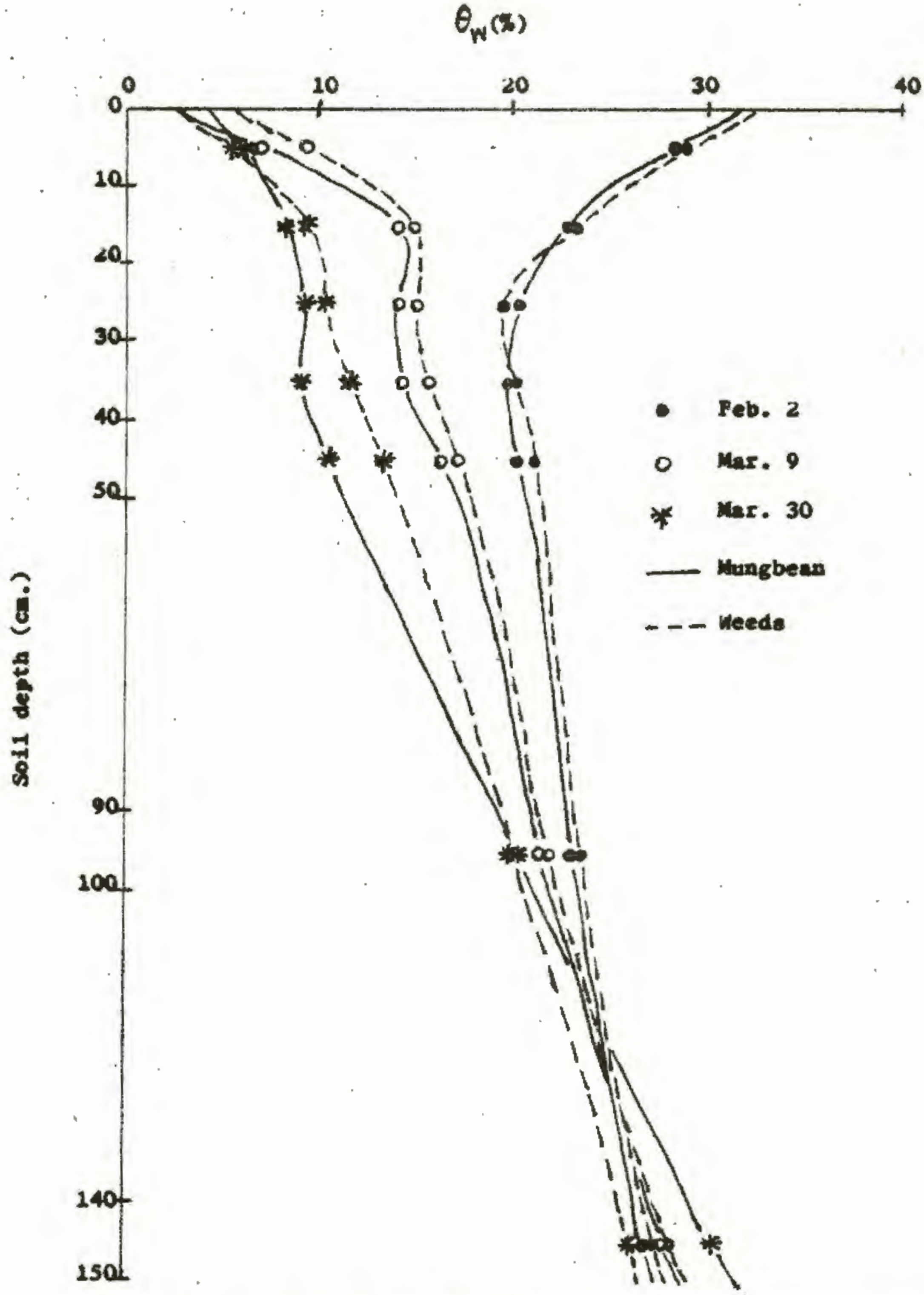


Figure 3. The effect of vegetation on soil moisture profile as selected for 3 dates of observation. Each data point replicated 4 times.

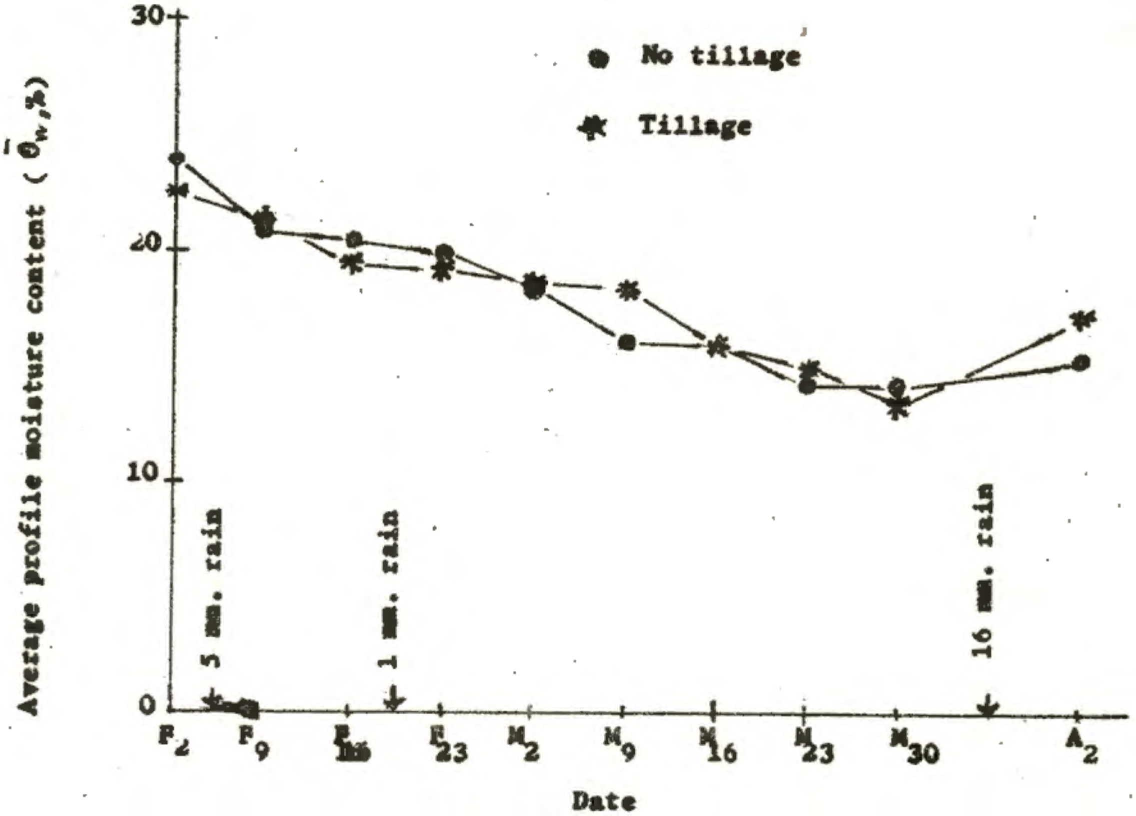


Figure 4. The effect of tillage practice on $\bar{\theta}_w$ throughout the growing season. Double weighted average ($\bar{\bar{\theta}}_w$) for tillage and no tillage plots are 18.5 % and 18.3 %, respectively.

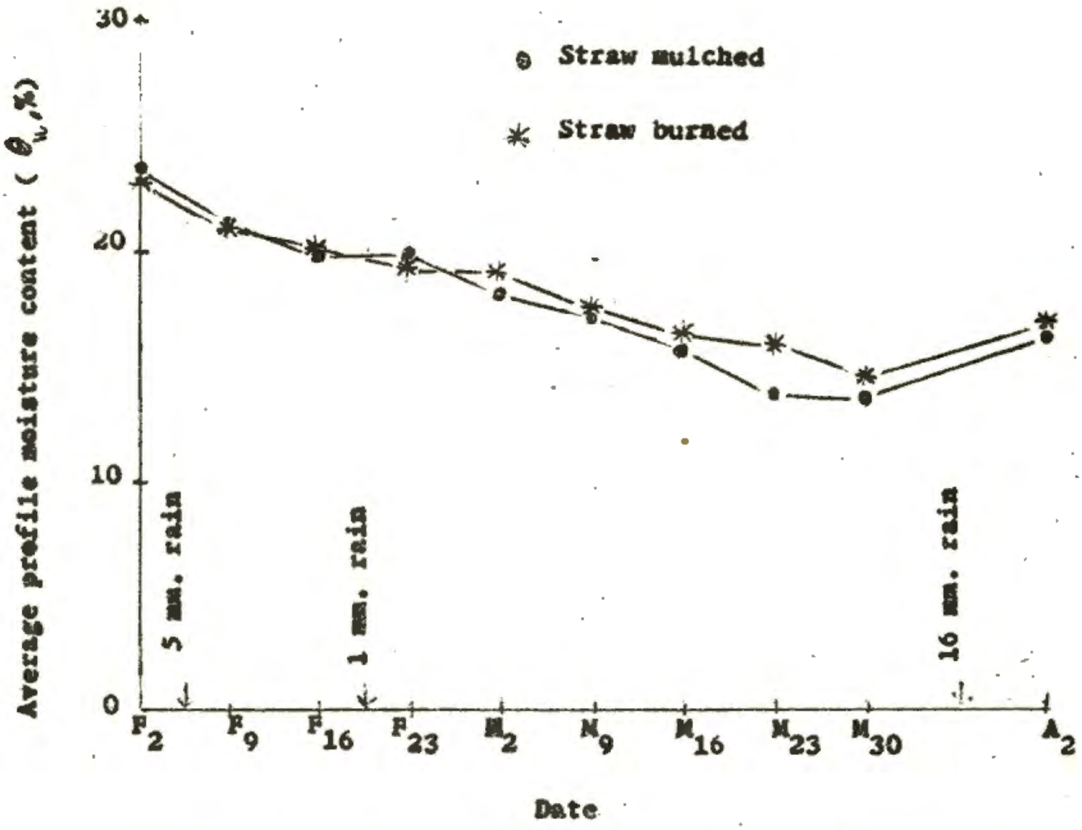


Figure 5. The effect of surface mulching on $\bar{\theta}_W$ throughout the growing season. Double weight average ($\bar{\bar{\theta}}_W$) for straw burned and straw mulched plots are 18.6 % and 18.2 % respectively.

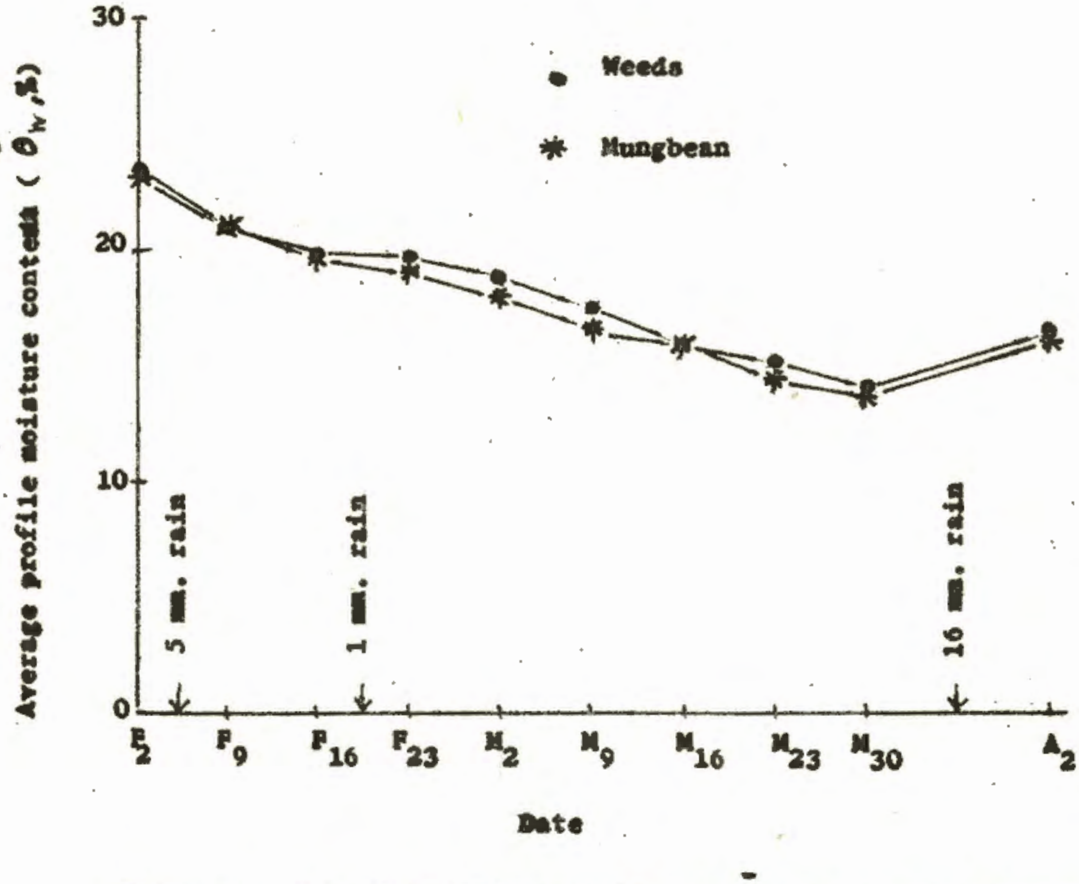


Figure 6. The effect of vegetation on $\bar{\theta}_W$ throughout the growing season. Double weighted average ($\bar{\bar{\theta}}_W$) for weeds and mungbean plots are 18.5 % and 18.2 %, respectively.

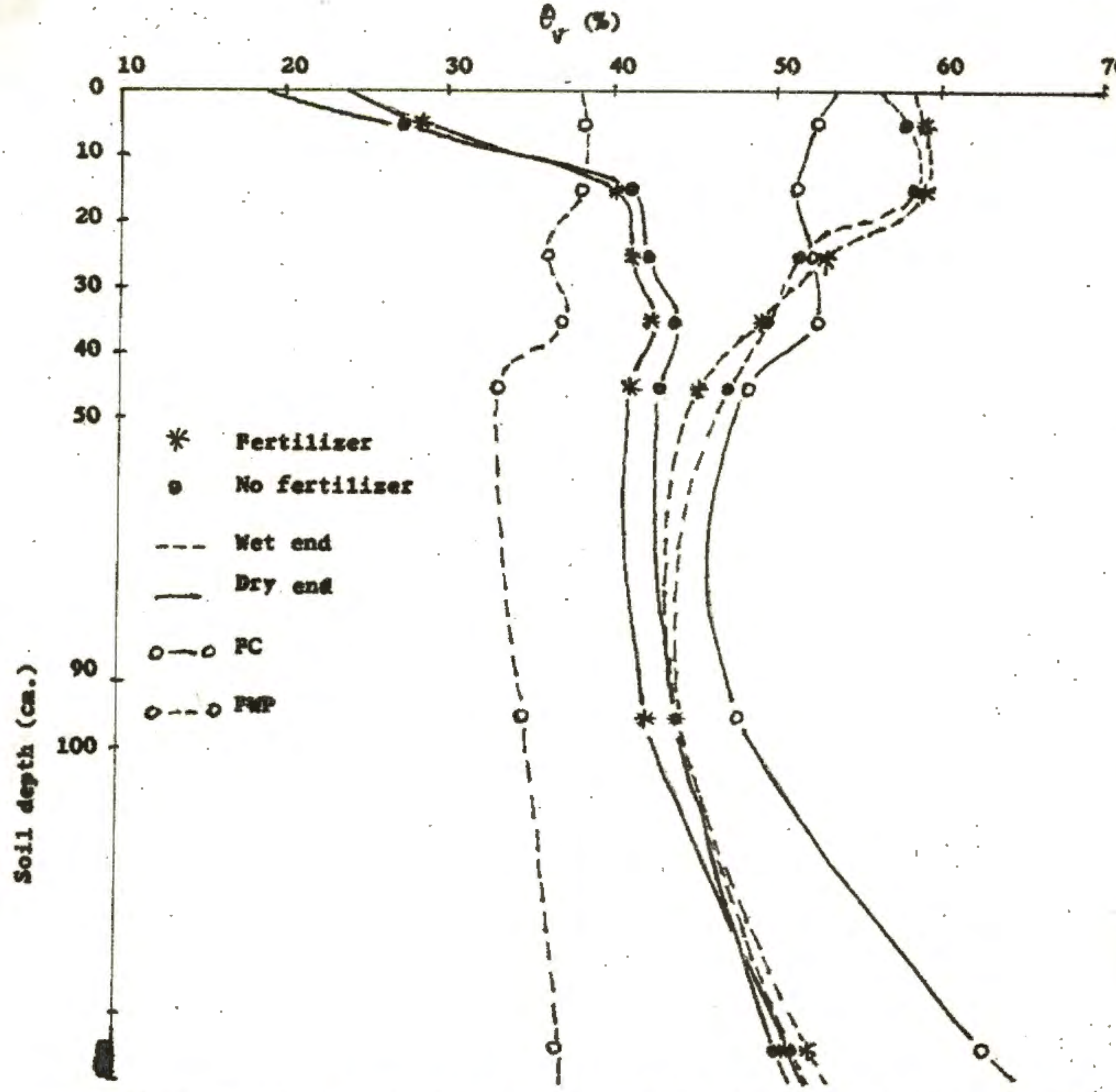


Figure 7. Average throughout the growing season of wet and dry end of profile moisture in response to different fertilization.

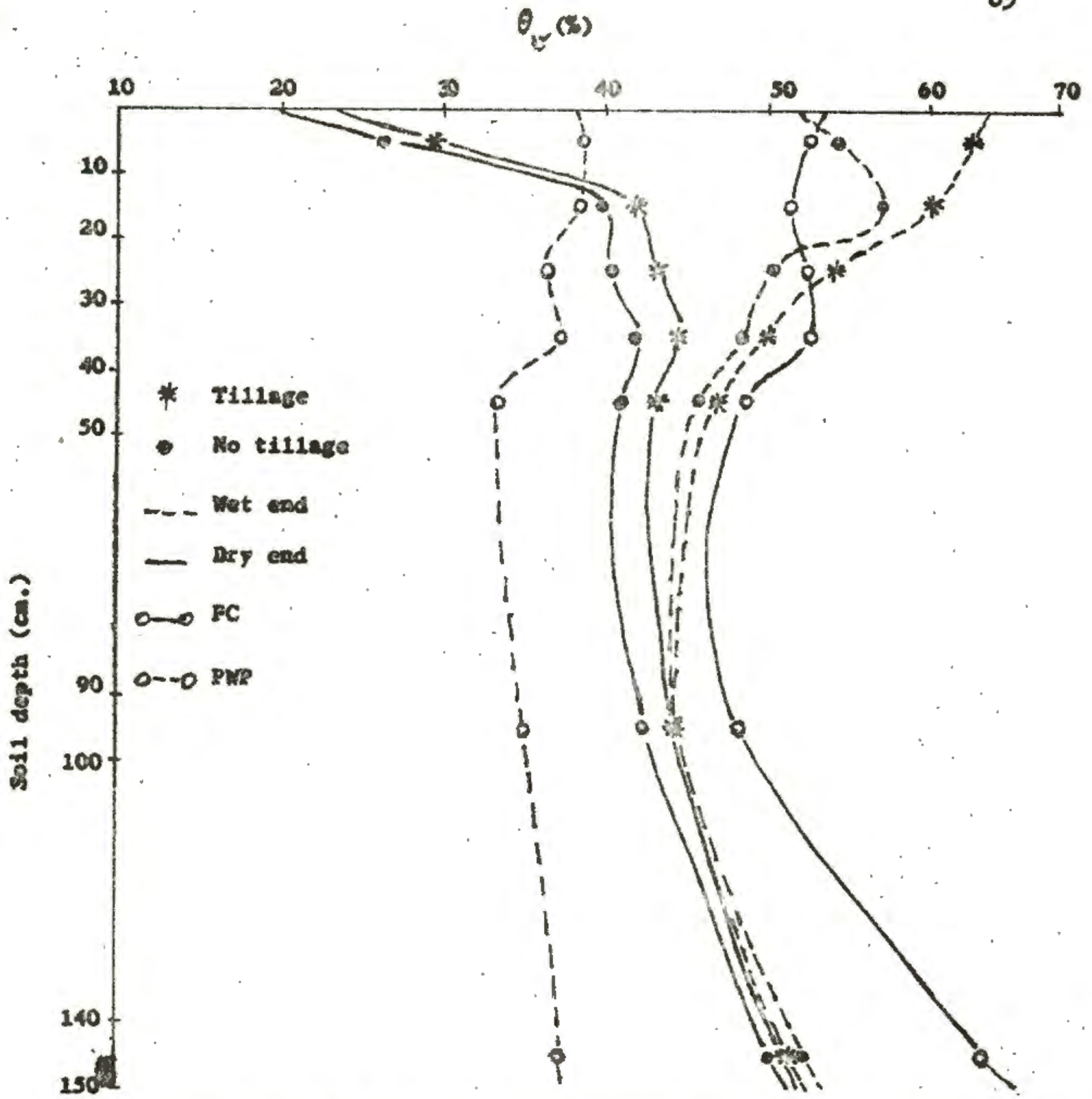


Figure 8. Average throughout the growing season of wet and dry end of profile moisture in response to different tillage management.

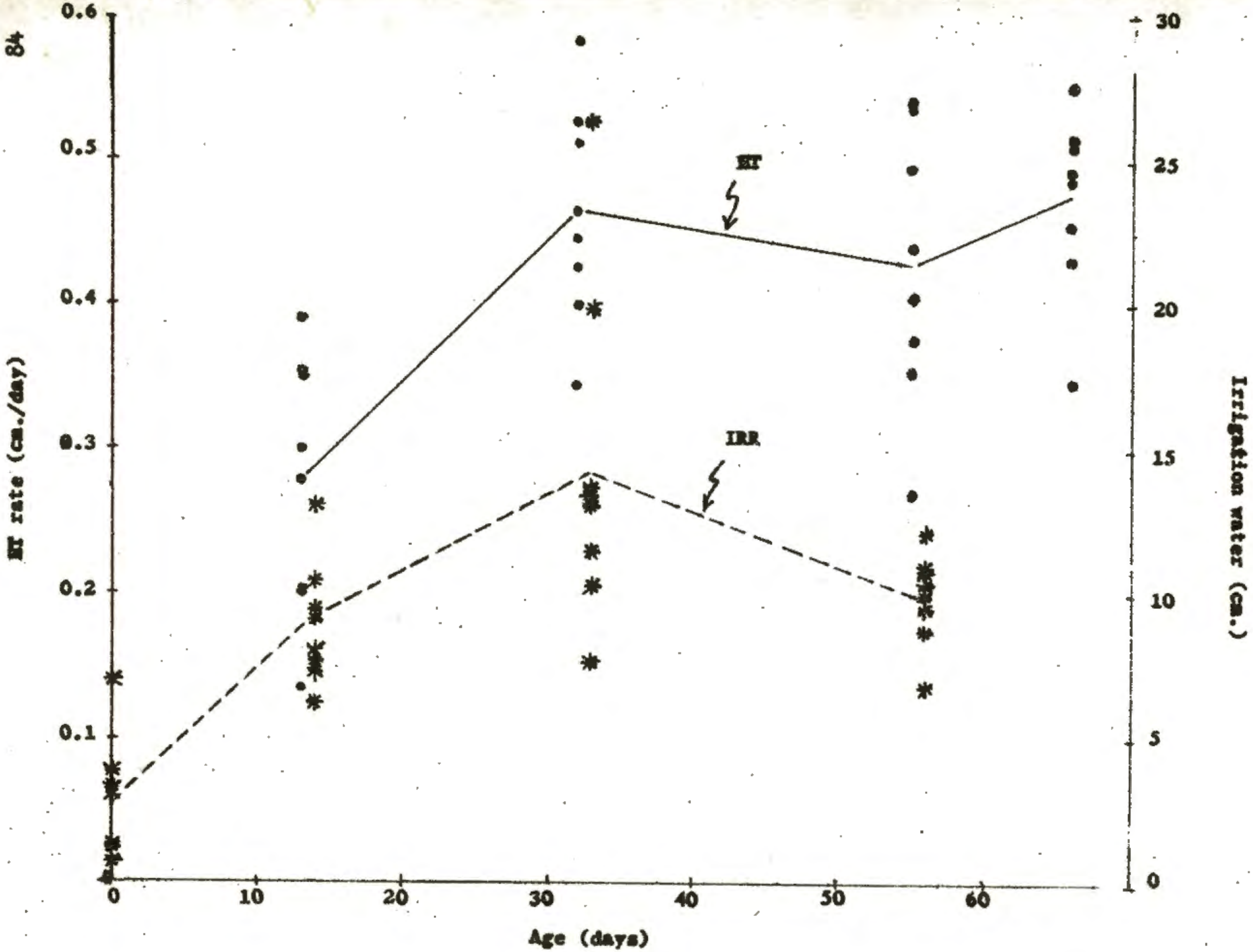


Figure 9. Evapotranspiration rate of mungbean at different age, the amount of irrigation water in each cycle is also illustrated.

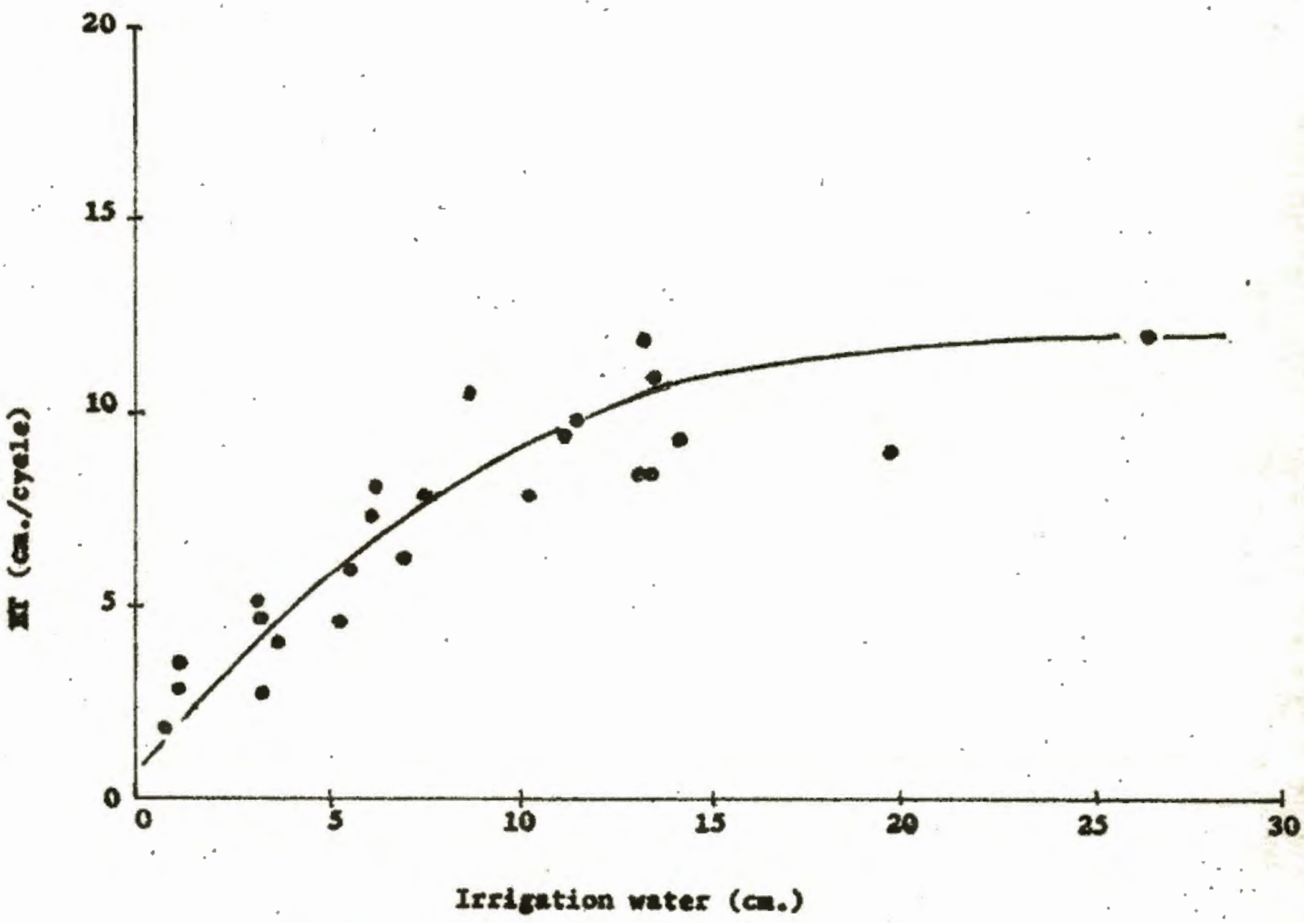


Figure 10. Total amount of evapotranspiration during each irrigation cycle as a consequence of the amount of the leaching irrigation water.

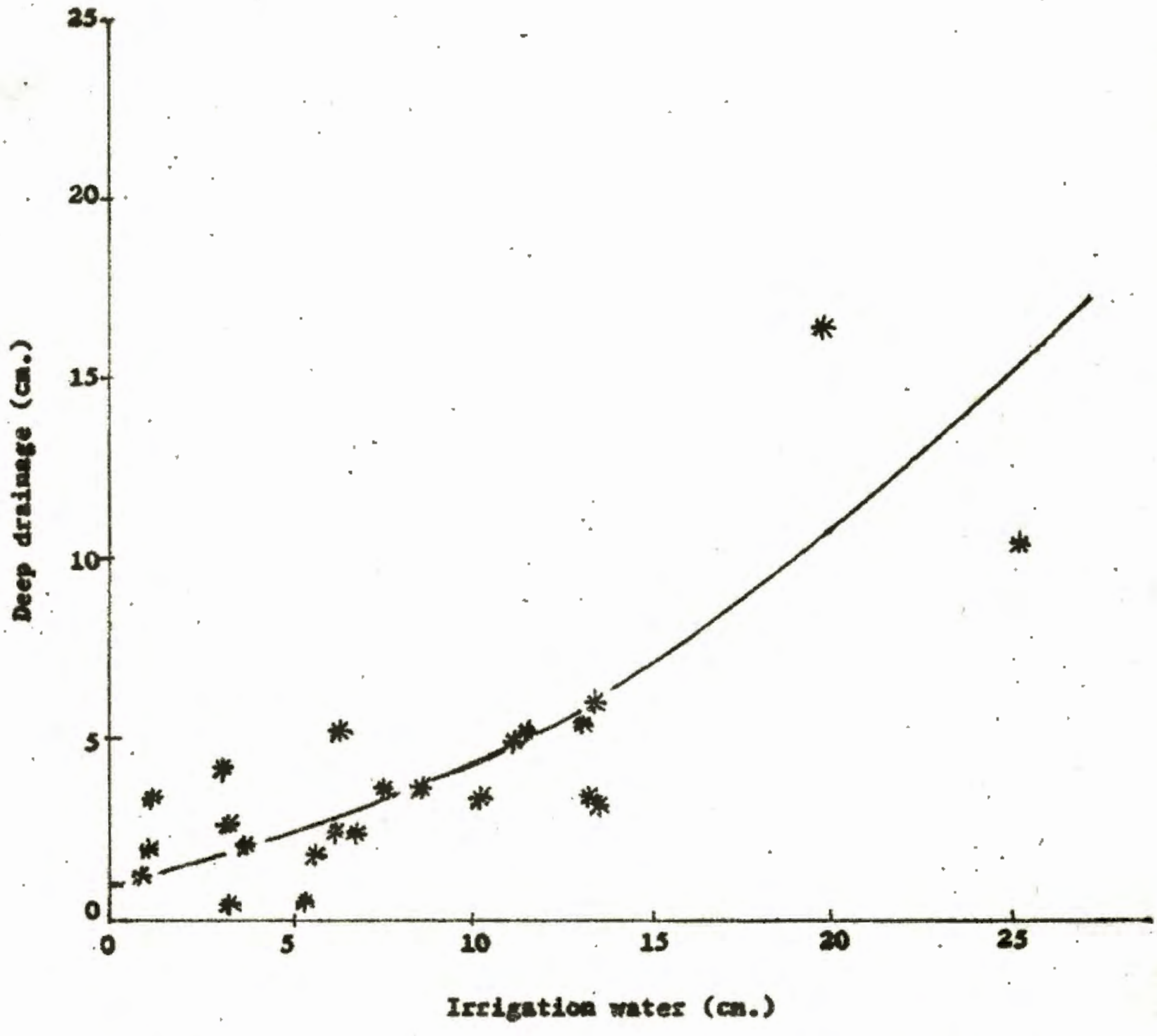


Figure 11. Deep drainage beyond 150 cm. depth as affected by the amount of irrigation water.

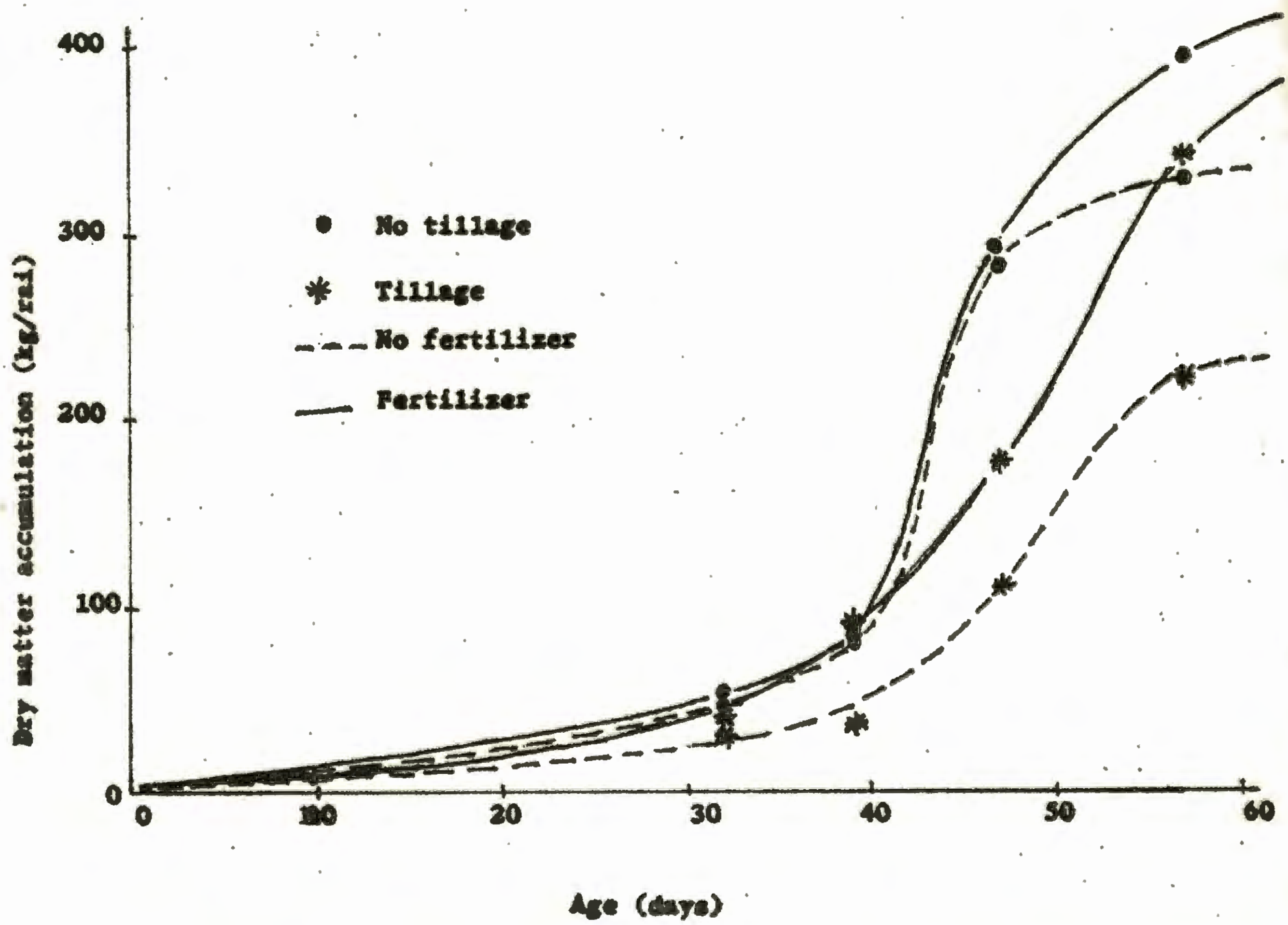


Figure 12. Typical s-shape curves of dry matter accumulation of mungbean grown under different surface managements.

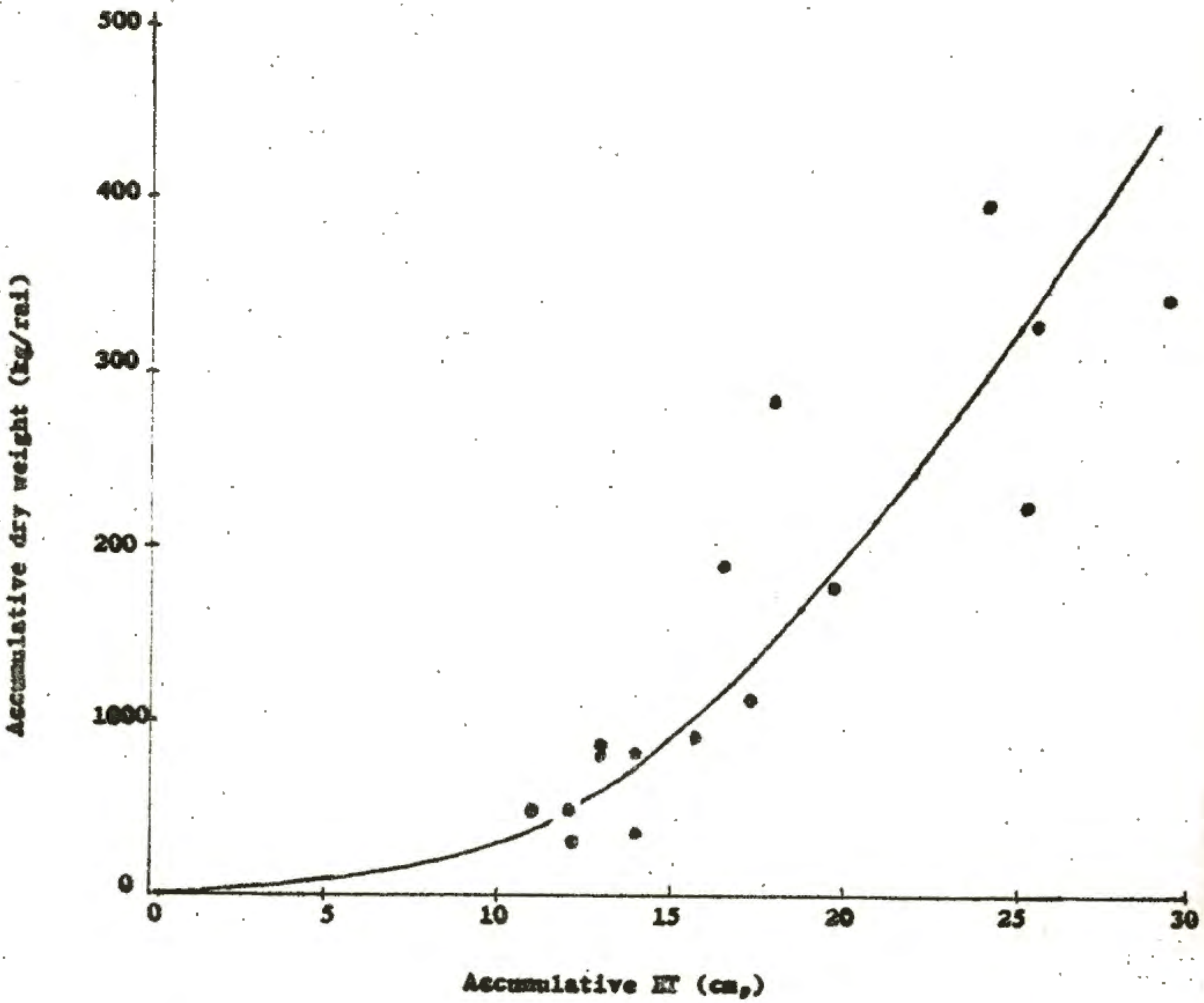


Figure 13. Dry weight accumulation of mungbean in response to the accumulative evapotranspiration.