Kasetsart J. (Nat. Sci.) 34 : 197 - 204 (2000)

Tillage and Mulching Affect on Growth and Yield of Cowpea Grown Following Rice in the Post-Monsoon Season of Northeastern Thailand

Anan Polthanee and Sadudee Wannapat

ABSTRACT

Field studies were conducted to assess the effects of tillage and no-tillage with and without mulch on the growth and yield of cowpea grown following rice in the post-monsson season of Northeastern Thailand. The results showed that growth and yield of cowpea were not significantly affected by tillage. There was slightly higher seed yields in tilled plots. This was attributed to tillage operation which is known to improve soil aeration. Mulch application significantly increased the leaf area per plant, total top dry weights, tap root length, root dry weight per plant and seed yield of cowpea. This was due to the better ability of mulched plots in storing soil moisture during the growing season.

Key words : cowpea, tillage, mulching, sequential cropping

INTRODUCTION

Dryland crops grown following wetland rice is an important component of rainfed rice-based cropping systems in some parts of south-east Asia. It offers prospects of being extended into other parts of the region where they are not widely grown (Angus, *et al.*, 1983). Dryland crops have the advantage of providing farm income for the rice grower in dry season and a source of nutrient for the rice crop in the coming rainy season when the stover is incorporated into the soil.

There were no significant differences in the cowpea yield of tilled and untilled plots, but the lower average yield on untilled plots appeared to be the result of poorer physical soil condition (Simpson and Gumbs, 1985). Tillage improved soil aeration and provide a good physical seedbed condition for seed germination and plant growth (Jensen *et al*., 1964). Although the yield of crops on untilled plots was slightly lower than that of tilled plots, the economic return from untilled plots, in general, was higher than that of tilled plots (Syarifuddin, 1982).

Cowpea crop grown following rice in the post-monsoon season of northeastern Thailand produced poor yield due to the exposure of crops to water stress during seed-filling phase (Polthanee, 1997). Mulching had positive effects on soil moisture conservation and improved cowpea yield (Kamara, 1981; Simpson and Gumbs, 1986a). This study was therefore, undertaken to examine the response of cowpea to tillage, no-tillage and mulching, no-mulching on the paddy field in the post-monsoon season of northeastern Thailand.

Department of Agronomy, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.

MATERIALS AND METHODS

The experiment was conducted at the farmer's field in Ban Kokyai, Ban Fang district, Khon Kaen province. The soil was a typic Hapleudaff of the order Alfisol. The texture of the soil is sandy loam with pH 4.6, 0.43% organic matter content, 0.016% total N, 14.6 ppm available P and 29.5 ppm exchangeable K. A split plot design was used with tillage and no-tillage as main plots, as well as mulching and no-mulching as sub-plots. There were four replications. The tilled plots were ploughed twice and harrowed once. The untilled plots were sprayed with Gramoxone (paraquat) before planting. Two to three seeds of cowpea were planted per hill and seedlings were thinned to one plant per hill at 7 days after planting (DAP). The spacing used was 50 cm between rows and 20 cm within rows. Fertilizer 15-15-15 at the rate of 156 kg ha^{-1} was applied at planting in a drill 5 cm deep and 10 cm away from the seeds. The rice straw mulch at the rate of 2 ton ha^{-1} was applied between rows at 7 DAP. Azodrin, an insecticide, was sprayed onto the cowpea plant twice during the growing season. Weed control was done once by hand weeding.

Rainfall was recorded during the growing season. Observation wells of perforated PVC tubes were installed at 1.50 m depth. Water table depth was measured at 7 DAP and weekly interval thereafter until harvest. Soil moisture contents of samples from 0-15 and 15-30 cm depth were determined using the gravimetic procedure at 7 DAP and at weekly interval thereafter until harvest. Soil temperatures were measured at the 10 cm depth at 12.00 h using Multimeter (Aquater Instrument Inc., U.S.A.).

Air–filled porosity was determined at 0-10 cm depth using soil core sampler. Air-filled porosity was calculated using the formula set by Russel (1949).

Eight plants from each replication were taken at days 15, 30 and 60 after sowing. and used for dry weight and leaf area measurements The final grain yields and number of pods per plant were determined from 40 plants taken from each replication. Seed number per pod and 100 seeds weight were determined from 100 pods. Tap root length and root dry weights were determined from eight plants taken from each replication at harvest. The data were analyzed using analysis of variance procedures and LSD were calculated where F-tests were significant.

RESULTS AND DISCUSSION

Rainfall and water table depth

The crops received rainfall once 35 days after planting during the growing season. Therefore, the amount of water available to the crops was mainly from the upward movement of water from the shallow water table. The measured water table depths ranged from 80 to 120 cm depth, and the recession was in the order of 1 to 10 cm/day during the growing season (Figure 1). The water table depth was set up to a depth of about 100 cm for 56 days. Doorenbos and Pruitt (1975) reported that water contribution to the root zone can be greater than 1 mm/day for the sandy loam at the groundwater depth of 100 cm below the root zone.

Soil moisture content and soil temperature

Mulched plots gave higher soil moisture content than that of unmulched plots at 0-15 and 15-30 cm depth with both tilled and untilled plots (Figure 2, 3). Irrespective of soil temperature, mulched plots had a lower soil temperature than that of unmulched plots (Figure 4). Mulches are known to decrease soil moisture loss by creating a thick static layer above the soil surface which acts as a layer that reduces both soil temperature and the evaporative loss of water (Priha *et al.*, 1981;

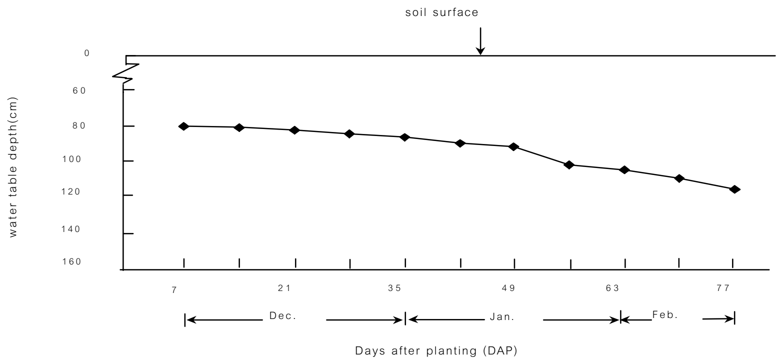

Figure 1 Water table depth fluctuation during the entire experimental period.

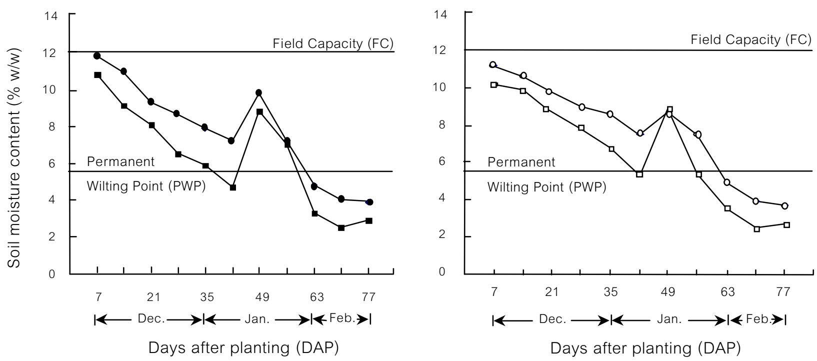

Figure 2 Soil moisture contents at the 0-15 cm depth of the tillage + mulching (●——●), tillage + no - mulching (■——■), no tillage + mulching (○——○) and no tillage + no mulching (□——□) treatments during the entire experimental period.

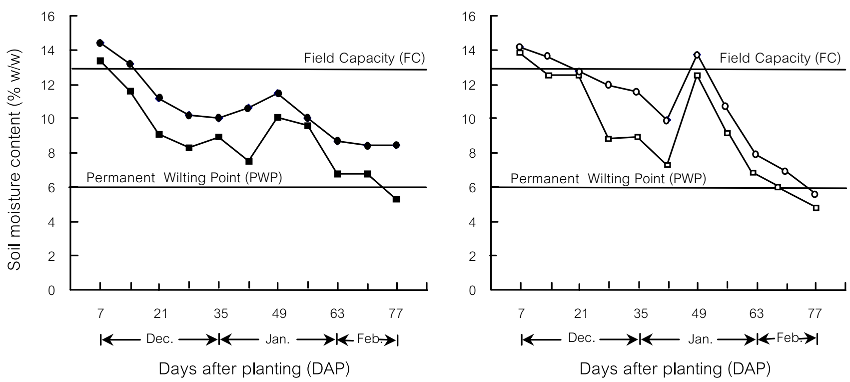

Figure 3 Soil moisture contents at the 15-30 cm depth of the tillage + mulching (●——●), tillage + no - mulching (■——■), no tillage + mulching (○——○) and no tillage + no mulching (□——□) treatments during the entire experimental period.

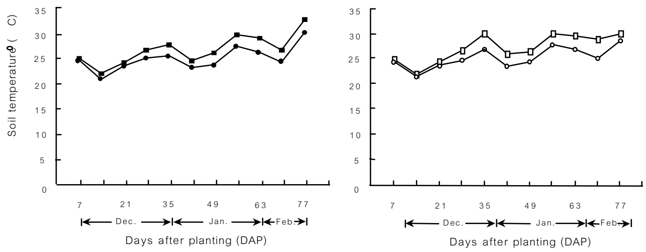

Figure 4 Soil temperature at the 10 cm depth of the tillage + mulching (●——●), tillage + no - mulching (■——■), no tillage + mulching (○——○) and no tillage + no mulching (□——□) treatments during the entire experimental period.

Simpson and Gumbs, 1986a; Unger, 1987). In this study, the soil moisture content of 0-15 cm depth of both mulched plots and unmulched plots could be remained in the available range (between field capacity and permanent wilting point), except during the last two weeks the soil moisture content showed below permanent wilting point (Figure 2). However, the soil moisture content at 15-30 cm depth was always above permanent wilting point. This was attributed to the upward movement of water from shallow water table (Figure 1). With soil temperature, mulched plots gave lower soil temperature at 10 cm depth than that of unmulched plots, ranging from 0.4 to 2.8°C during the growing season. Mulches application reduced soil temperature was also reported by Simpson and Gumbs (1986a). Walker (1969) pointed out that even an 1°C difference in soil temperature could have significant effect on plant growth. During the growing period, however, soil temperature in the plant root zone could range from 21 to 33°C. It may not reach as high as 40°C which is enough to effect the plant growth.

Air–filled porosity

Considering air-filled porosity (AFP) at 0, 15, 30, 45 and 60 days after planting, the results showed that AFP was higher with tilled plots than with of untilled plot (Table 1). Tillage is generally known to improve soil physical properties. Jensen *et al.* (1964) reported that tillage operation improved soil aeration. While Simpson and Gumbs (1985) indicated that tillage operation provided higher percentage of soil macroporosity.

Leaf area and total top dry weight

Tillage methods did not significantly affect the leaf areas and total top dry weights of cowpea at 15, 30 and 60 days after planting (DAP). The leaf area and total top dry weight, however, were slightly higher in tilled plots (Table 2). This agreed with the work done by Gumbs and Lindsay (1993) and Gumbs *et al.* (1995). Irrespective of mulching, there was significantly increased in leaf area and total top dry weight per plant of mulched plots at 30 and 60 DAP (Table 2). This could be the result of the capacity of mulched plots to store more soil moisture than that of unmulched plots (Figures 2, 3).

Tap root length and root dry weight

Tillage methods did not significantly affect the tap root length and root dry weight of cowpea (Table 3). Mulched plots had longer tap roots and higher root dry weights than that of unmulched plots (Table 3). This could be the result of greater soil moisture content of the mulched plots (Figures 2, 3). Mulch application increased root dry weights

Table 1 Air – filled porosity (%) at 0-10 cm soil depth as influenced by tillage and mulching treatments.

Treatment	Days after planting				
	0	15	30	45	60
Tillage (T)					
Till (T1)	30.4 a	28.3 a	31.0 a	37.2 a	45.8 a
No-till (T2)	16.3 b	21.4 b	23.6 b	24.5 b	30.1 b
Mulching (M)					
Mulch (M1)	23.6	25.4	27.3	30.8	37.1
No-mulch (M2)	23.1	24.3	27.3	30.9	38.8
Tillage x Mulching					
T1M1	30.8	29.6	31	37.4	44.8
T1M2	29.9	27	30.9	37	46.8
T2M1	16.3	21.2	23.5	24.2	29.4
T2M2	16.2	21.5	23.6	24.8	30.7
Tillage (T)	**	**	**	**	**
Mulching (M)	NS	NS	NS	NS	NS
T x M	NS	NS	NS	NS	NS

Values in the same column followed by the same letter are not significantly different at the 0.05 level.

of cowpea (Simpson and Gumbs, 1986; Lindsay, 1993; Gumbs *et al.*, 1995). Mulch application increased tap root length was also reported by Kamara (1981).

Yield components

Tillage methods were significantly affected the number of seeds per pod, but not the number of pods per plant and 100 seeds weight (Table 4). Tilled plots gave higher number of seeds per pod than that of untilled plots. This was probably due to tillage operation which improved soil aeration (Table 1). Mulch application significantly increased the number of pods per plant and number of seeds per pod (Table 4). This was because mulched plots gave higher leaf area and total top dry weight per plant (Table 2).

Seed yield

There were no significant differences in yields of tilled and untilled plots. However, the higher average yield was obtained from tilled plots. This was attributed to the higher number of seeds per pod of tilled plots (Table 4). Simpson and Gumbs (1985) reported that the lower average yield of untilled plots resulted from poorer physical soil conditions, although there were no significant differences in the yield of tilled and untilled plots. Irrespective of mulching, the results showed that mulch application was significantly increased in seed yield. These were attributed to the higher number of pods per plant and the number of seeds per pod of mulched plot (Table 4). Simpson and Gumbs (1986 b) reported that mulched plots gave higher seed yield than that of unmulched plots which was due to greater number of pods per plant

Table 2 Leaf areas (LA, cm^2/ plant) and total top dry weights (DW, g/ plant) of cowpea at 15, 30 and 60 days after planting as influenced by tillage and mulching treatments in the post – monsoon season of Northeastern Thailand.

Treatment	Days after planting					
	15		30		60	
	LA	DW	LA	DW	LA	DW
Tillage (T)						
Till (T1)	47.3	0.53	189.2	1.96	532.5	5.3
No-till (T2)	45.4	0.51	180.2	1.8	531.3	5
Mulching (M)						
Mulch (M1)	49.8	0.56	214.7 a	2.35 a	632.3 a	6.3 a
No-mulch	42.9	0.48	154.7 b	1.42 b	431.6 b	3.9 b
Tillage x Mulching						
T1M1	52.3	0.58	220.2	2.46	649.1	6.5
T2M2	42.3	0.48	158.2	1.46	415.9	4
T2M1	47.3	0.54	209.2	2.23	615.4	6.1
T2M2	43.5	0.47	151.1	1.37	447.2	3.9
Tillage (T)	NS	NS	NS	NS	NS	NS
Mulching (M)	NS	NS	**	**	**	**
T x M	NS	NS	NS	NS	NS	NS

Values in the same column followed by the same letter are not significantly different at the 0.05 level.

Table 3 Tap root length and root dry weight of cowpea at harvest as influenced by tillage and mulching treatments in the post-monsoon season of Northeastern Thailand.

Treatment	Tap root length (cm)	Root dry weight (g/plant)
Tillage (T)		
Till (T1)	17.4	1.34
No-till (T2)	16.4	1.27
Mulching (M)		
Mulch (M1)	18.6 a	1.64 a
No-mulch (M2)	15.2 b	0.97 b
Tillage x Mulching		
T1M1	19.2	1.7
T1M2	15.5	0.97
T2M1	17.9	1.57
T2M2	14.9	0.96
Tillage (T)	NS	NS
Mulching (M)	**	*
T x M	NS	NS

Values in the same column followed by the same letter are not significantly different at the 0.05 level.

Table 4 Seed yields and yield components of cowpea as influenced by tillage and mulching treatments in the post-monsoon season of Northeastern Thailand.

Treatment	Pod/plant	Seeds/pod	100-seeds weight (g)	Seed yield (kg/ha)
Tillage (T)				
Till (T1)	8.4	8.2 a	18.7	841.5
No-till (T2)	8.2	6.7 b	18.3	804
Mulching (M)				
Mulch (M1)	9.1 a	7.6 a	18.9	940.6 a
No-mulch (M2)	7.5 b	6.3 b	18.1	704.9 b
Tillage x Mulching				
T1M1	9.2	8.9	18.9	965.8
T1M2	7.5	7.4	18.4	717.2
T2M1	9	7.3	18.8	915.3
T2M2	7.4	6.1	17.7	692.5
Tillage (T)	NS	*	NS	NS
Mulching (M)	*	*	NS	**
T x M	NS	NS	NS	NS

Values in the same column followed by the same letter are not significantly different at the 0.05 level.

and 100 seeds weight. Mulch application led to the increment of seed yields of cowpea was also reported by Kamara (1981).

CONCLUSION

Tillage operation did not significantly affect the dry seed yields of cowpea. However, the slightly greater average seed yields of tilled plots over untilled plots caused by better soil physical conditions. Mulch application improved the seed yields of cowpea could be the result of its capacity to store more soil moisture. To obtain a satisfactory yield of cowpea grown following rice in the post-monsoon season during the rainless period, however, shallow depth of groundwater table to provide upward movement of water to the root zone should be considered.

LITERATURE CITED

Angus, J.F., S. Hasegawa., T.G. Hsiao, S.D. Liboon, and H.G. Zandstra. 1983. The water balance of post-monsoonal dryland crops. J. of Agric. Sci. 101 : 699-710.

Doorenbos, J. and W.O. Pruitt. 1975. Guidelines for Predicting Crop Water Requirements. Food and Agriculture Organization, Rome. Irrig. Drainage Pap. 24 p.

Gumbs, F.A. and J.I. Lindsay. 1993. Effect of soil water and tillage on cowpea growth and yield on a clay soil. Trop. Agric. 70 : 27-32.

Gumbs, F.A., L.A. Simpson, and J.I. Lindsay. 1995. Tillage and drainage management of clay soils for the continuous production of annual crops under rainfed conditions in the humid tropics. Trop. Agric. 72 : 28-33.

Jensen, D.R., J. Letey, and L.H. Stolzy. 1964. Labelled oxygen transport through growing corn roots. Science. 144 : 550-551.

Kamara, D.S. 1981. Effects of planting date and mulching on cowpea in Sierre Leone. Expl Agric. 17 : 25-31.

Polthanee, A. 1997. Rice – based cropping systems in Northeastern Thailand, pp. 13-22. *In* S. Fukai, M. Cooper and J. Salisbury (eds.). Breeding Strategies for Rainfed Lowland Rice in Drought–prone Environment. ACIAR Proceedings No.77, Canberra.

Priha, S.S., K.S. Sandhu, Y. Singh, and R. Singh. 1981. Effect of nitrogen rate on dryland wheat in relation to mulching previous crop fallow. Fert. Res. 2 : 211-219.

Russell, M. B. 1949. A simplied air pycnometer for field use. Soil Sci. Soc. Am. Proc. 14 : 73-76.

Simpson, L.A. and F.A. Gumbs. 1985. A comparison of conventional tillage and no-tillage for cowpea production. Trop. Agric. 62 : 248-252.

Simpson, L.A. and F.A. Gumbs. 1986a. A system of crop and soil management for the wet season production of food crops on a heavy clay soil in Guyana : a. Effect of mulching and tillage on soil properties and crop yields. Trop. Agric. 63 : 305-310.

Simpson, L.A. and F.A. Gumbs. 1986b. A system of crop and soil management for the wet season production of food crops on a heavy clay soil in Guyana : b. Effect of mulching and tillage on germination, growth, nutrient uptake and yield. Trop. Agric. 63 : 311-315.

Syarifuddin, A.K. 1982. Tillage practices and methods of seeding upland crops after wetland rice, pp. 34-41. *In* Cropping Systems Research in Asia. The International Rice Research Institute; Los Banos, Laguna.

Unger, P.W. 1987. Straw mulch rate effect on soil water storage and sorghum yield. Soil Sci. Soc. Am. J. 42 : 486-491.

Walker, I.M. 1969. One degree increments in soil temperatures affect maize seedling behaviour. Soil Sci. Soc. Am Proc. 33 : 729-733.

Received date : 24/09/99
Accepted date : 14/02/00