Kasetsart J. (Nat. Sci.) 35 : 51 - 59 (2001)

The Effects of Field Ridging and Flat-Field Planting on Growth and Yield of Three Legumes Grown Before Rice in the Pre-Monsoon Season of Northeastern Thailand

Anan Polthanee

ABSTRACT

Field studies were conducted to assess the effects of field ridging and flat-field planting on the growth, yield and economic return of mungbean, cowpea and soybean grown before rice in the pre-monsoon season of Northeastern Thailand. The results showed that growth and yield of the 3 legumes were not significantly affected by field ridging. However, there was higher net income in flat-field planting treatments. This was attributed to high labour cost for ridge construction. Cowpea gave the highest seed yield with both field ridging and flat field planting treatments as compared with mungbean and soybean. In economic terms, however, soybean gave the maximum net return with flat-field planting treatments.

Key words: mungbean, cowpea, soybean, field ridging, sequential cropping

INTRODUCTION

In many tropical rainfed lowland rice-growing areas, production of a pre-rice crop offers an attractive alternative to increase farm income. The early rains can be used successfully to grow a short-maturing upland crop, whereas rice is transplanted later in the season as rains intensify. However, the major constraint in upland crop production early in the rainy season is waterlogging due to intermittent heavy rains, which pond on poorly drained ricelands (KKU-FORD, 1978 ; Zandstra 1982; Polthanee, 1997). Intermittent shallow surface flooding is prolonged because the field can not be externally drained due to an insufficient field-to-field slope gradient. During periods when the soil is saturated, severe oxygen deficiency rapidly develops in the roots, causing root death (Herrera and Zandstra, 1979).

Mungbean, cowpea and soybean are the most commonly grown grain legumes on tropical riceland during the dry-wet transitions in the early rainy season. Stable production of the crop in many areas will depend on improved agronomic practices to counteract temporary waterlogging. The purpose of this study was to determine the effects of two field-level drainage situations (ridging and flat-field planting) on growth and yield of mungbean, soybean and cowpea on the paddy field in the pre-monsoon season of Northeastern Thailand.

MATERIALS AND METHODS

The experiment was conducted at the farmer's field in Ban Muangyai, Muang district, Khon Kaen province. The soil was an Oxic Paleustults. The texture of the soil is sand loam with pH 4.5, 0.59% organic matter content, 0.03% total N, 5.7 ppm available P and 34.2 ppm exchangeable K. A split plot design was used with field ridging

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

and flat-field planting as main plots, as well as three legumes as sub-plots. There were four replications.

The field was thoroughly plowed twice by 6 horsepower hand tractor and harrowed twice. Dolomite was incorporated into the soil at the rate of 625 kg/ha during the harrowing. Ridge bodies were constructed by hand tractor as well as hand hoe before planting. The ridges were 75 cm wide with a 50 – cm furrow in between (Figure 1). Two rows of 3 legumes were planted on the ridges with plant spacing of 35×20 cm. The plant spacing used was 50×20 cm in the flat conventional planting treatments. Four to five seeds of mungbean, soybean and cowpea were planted per hill and seedlings were thinned to two plants per hill at 10 days after planting (DAP) in both the ridge and flat-field planting treatments. The plant population was 175,000 and 200,000 plants ha^{-1} in ridge and flat-field planting treatments, respectively. Fertilizer 12-24-12 at the rate of 156 kg ha^{-1} was applied in ridge treatments and at the rate of 188 kg ha^{-1} in flat-field planting treatments in a drill 5 cm deep and 10 cm away from the seeds 10 DAP. Azodrin, an insecticide, was sprayed onto the mungbean, soybean and cowpea twice during the growing season. Weed control was done twice by hand weeding.

Rainfall, minimum and maximum temperatures were recorded during the growing season. Soil moisture contents of samples from 0-15 and 15-30 cm depth on top of the ridge and flat-field planting treatments were determined using the gravimetric procedure at 7 DAP and at weekly intervals thereafter until harvest.

Eight plants from each replication were taken at days 15, 35 and 55 after sowing, and used for dry weight and leaf area measurements. The final grain yields and number of pods per plant were determined from 30 plants taken from each replication. Seed number per pod and 100 seed weight were determined from 100 pods. Tap root length and root dry weights were determined from five 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 temperature

Total rainfall was about 497 mm during the growing period. There was no rain in week 9 after planting. The highest weekly rainfall was 117 mm, received in week 7 after planting (Figure 2). Mean weekly maximum and minimum temperatures were in the range of 30.7 to 34.1°C and 23.6 to 25.2°C, respectively (Figure 2). The highest daily temperature during the growing period was 36.0°C, recorded on 30 June 1999.

Soil moisture content

Flat-field planting treatments gave higher soil moisture content than those of the ridge treatments at 0-15 and 15-30 cm depth throughout the growing period (Figures 3 and 4). In this experiment, the crops were subjected to waterlogging (soil moisture content was above field capacity level) at 28 and 42 DAP in the flat-field planting treatment (Figures 3 and 4). This result indicated that ridging kept free water level at 15 cm soil depth. Polthanee (1989) reported that ridge treatments gave higher initial water infiltration rate into the soil as well as soil matric tension than those of the flat soil planting treatments.

Leaf area per plant

Drainage methods did not significantly affect the leaf areas at 15, 35 and 55 days after planting (DAP). The leaf areas, however, were slightly higher in ridge treatments (Table 1). This was due to the soil moisture content at 0-15 cm depth remaining in the available range (between field capacity and permanent wilting point) throughout the growing period (Figure 3). In the case of flat-field planting treatment, the soil moisture content at 0-15 cm depth was above field capacity at 28 and 45 DAP, indicating that the plants suffered from waterlogging

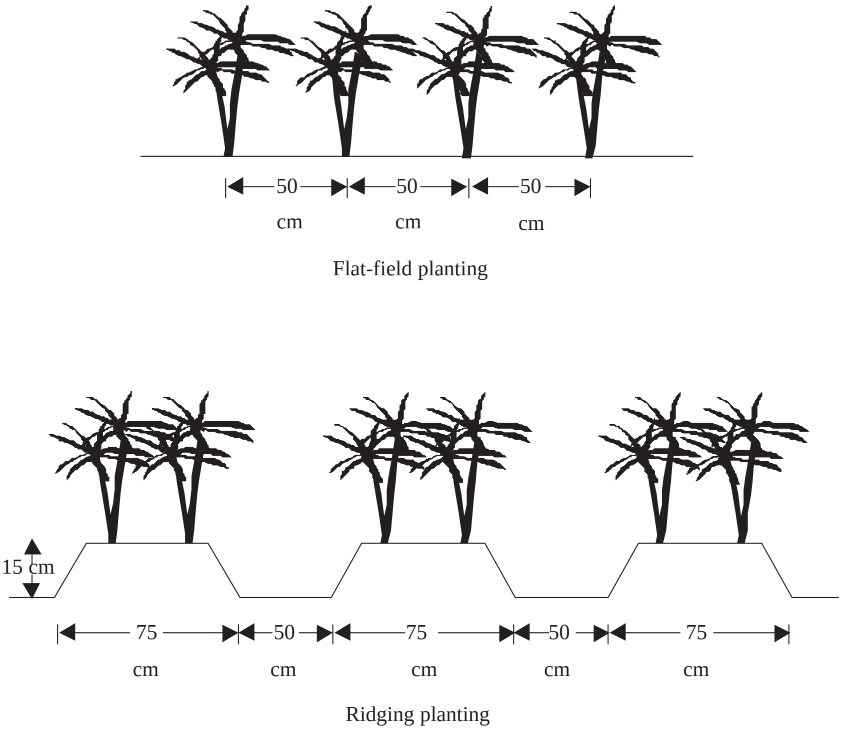

Figure 1 Field level drainage situation of flat-field planting and ridging.

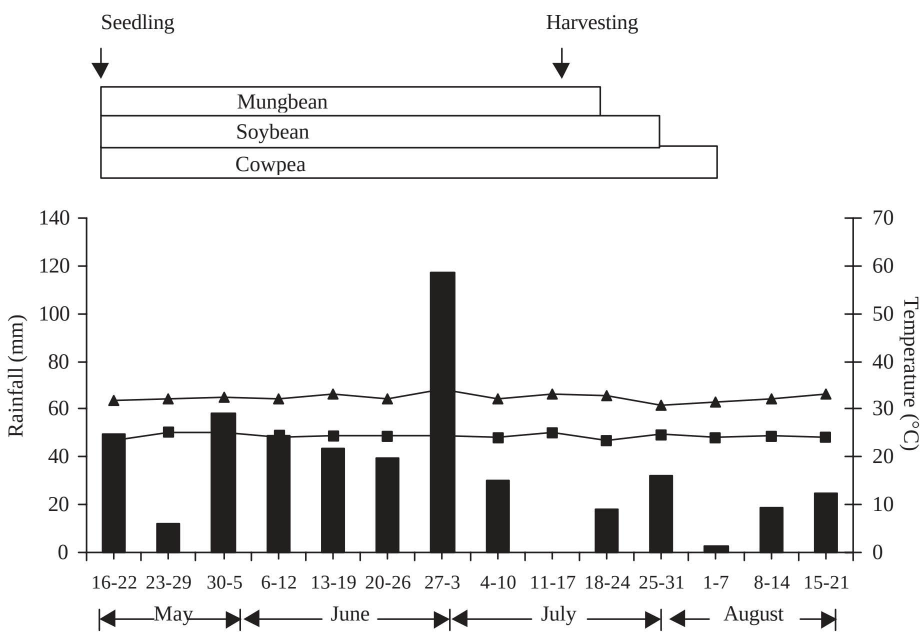

Figure 2 Weekly weather data for the experimental period : rainfall in 1999 shown by the columns, maximum temperature in 1999 (—▲—) and minimum temperature in 1999 (—■—) during the entire experimental period.

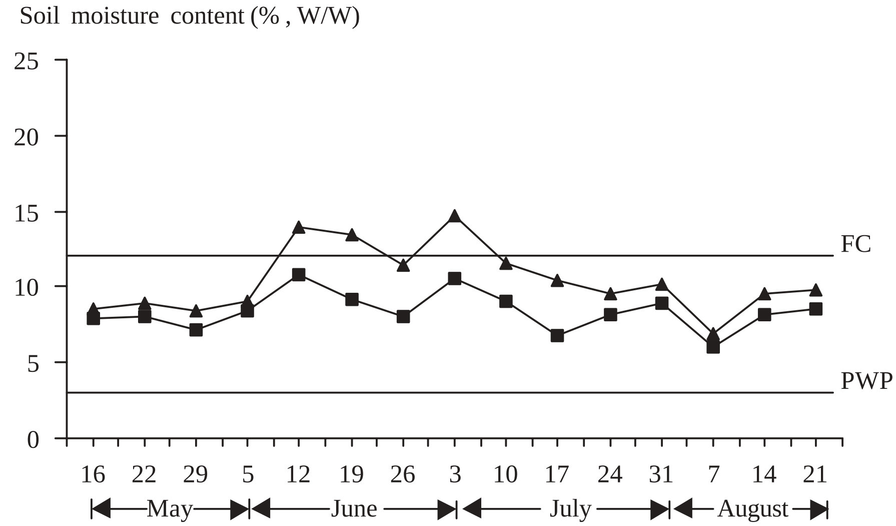

Figure 3 Soil moisture contents at 0-15 cm depth for the flat-field planting (—▲—) and ridging treatments (—■—) during the entire experimental period.

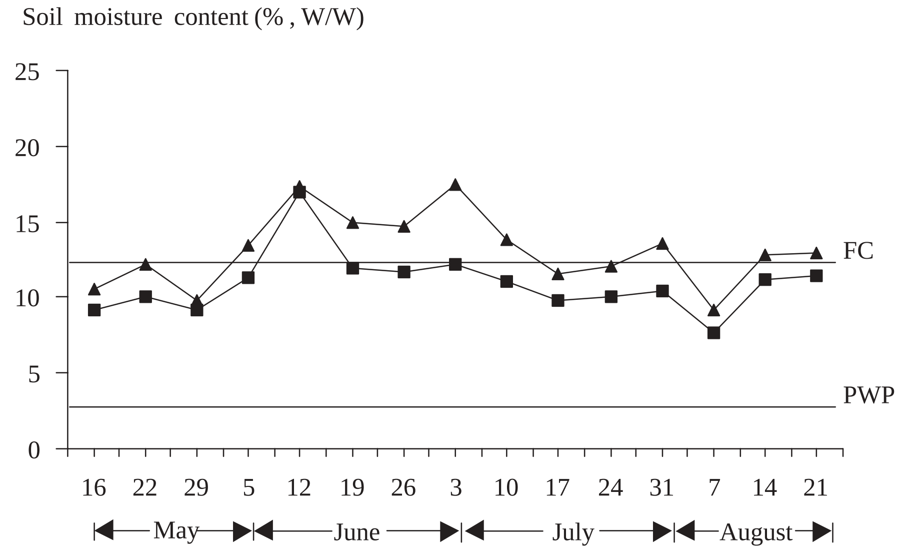

Figure 4 Soil moisture contents at 15-30 cm depth for the flat-field planting (—▲—) and ridging treatments (—■—) during the entire experimental period.

and the reduction in leaf areas per plant resulted. Mungbean, cowpea and soybean which were subjected to waterlogging during the vegetative phase showed decreased leaf areas as reported by Polthanee (1989), Gumbs and Lindsay (1993) and Sallam and Scott (1987). Irrespectively of crop species, there was significant difference in leaf areas of mungbean, cowpea and soybean at 15, 35 and 55 DAP (Table 1). Soybean gave the highest leaf areas at 15 and 35 DAP. However, the maximum leaf areas were obtained from cowpea at 55 DAP. There was an interaction effect for drainage methods

Table 1 Leaf areas (cm^2/plant) of 3 legumes at 15, 30 and 55 days after planting as influenced by ridge and flat-field planting treatments in the pre-monsoon season of Northeastern Thailand.

Treatments	Days after planting		
	15	35	55
Drainage (D)			
Ridge (D1)	39.0	444.1	916.2
Flat (D2)	31.3	322.9	673.2
Crop species (C)			
Mungbean (C1)	16.7b	261.4c	445.9c
Cowpea (C2)	26.3b	403.2b	1119.2a
Soybean (C3)	62.7a	486.0a	820.0b
Drainage x Crop species			
D1C1	18.1	319.6g	586.6
D1C2	30.1	436.8e	1236.2
D1C3	68.9	576.0d	928.0
D2C1	15.0	203.0h	305.3
D2C2	22.4	369.6fg	1002.3
D2C3	56.4	396.1ef	712.0
Drainage (D)	NS	NS	NS
Crop species (C)	**	**	**
DXC	NS	**	**

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

and crop species on the leaf areas at 35 DAP. This result indicated that the response to drainage methods by crop species was not consistent. This was due to a greater reduction in leaf area of soybean in the flat-field planting treatment.

Top dry weight per plant

Drainage methods did not significantly affect the top dry weight at 15, 35 and 55 DAP. The top dry weight, however, was slightly higher in ridge treatment (Table 2). This was due to higher leaf area per plant (Table 1). There was a significant difference in top dry weight per plant among crop species. Soybean gave the highest top dry weight at 15 DAP, whereas cowpea produced the maximum top dry weight at 35 and 55 DAP (Table 2).

Tap root length and root dry weight

Drainage methods did not significantly affect the tap root length and root dry weight at harvest of the 3 legumes. However, the tap root length and root dry weight were slightly higher in ridge treatment (Table 3). Irrespectively of crop species, there was significant difference in tap root length and root dry weight of mungbean, cowpea and soybean at harvest (Table 3). Cowpea gave the highest tap root length and root dry weight. There was an interaction effect for drainage methods and crop species on the root dry weight (Table 3). This result indicated that the response to drainage methods by crop species was not consistent. This was due to a lower reduction in root dry weight of soybean planted in the flat-field treatments.

Table 2 Top dry weight (g/plant) of 3 legumes at 15, 30 and 55 days after planting as influenced by ridge and flat-field planting treatments in the pre-monsoon season of Northeastern Thailand.

Treatments	Days after planting		
	15	35	55
Drainage (D)			
Ridge (D1)	192.9	644.2	1260.0
Flat (D2)	159.3	481.1	900.4
Crop species (C)			
Mungbean (C1)	105.2b	470.3a	740.3b
Cowpea (C2)	145.8b	652.7a	1666.7a
Soybean (C3)	227.3a	565.0b	833.7b
Drainage x Crop species			
D1C1	114.7	574.7	973.3
D1C2	163.7	706.7	1840.0
D1C3	300.3	651.3	966.7
D2C1	95.7	366.6	507.3
D2C2	128.0	598.7	1493.3
D2C3	254.3	478.7	700.7
Drainage (D)	NS	NS	NS
Crop species (C)	**	**	**
DXC	NS	NS	NS

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

Yield components

Drainage methods did not significantly affect the pods per plant, seeds per pod and 100-seed weight of the 3 legumes. The yield components, however, were slightly higher in ridge treatment (Table 4). This was attributed to the crops having higher leaf area per plant (Table 1) and top dry weight per plant (Table 2). There was a significant difference in yield components of mungbean, cowpea and soybean. Soybean gave the highest pods per plant. Cowpea gave the highest seeds per pod and 100-seed weight (Table 4). There was an interaction effect for drainage methods and crop species on the seeds per pod, indicating that the response to drainage methods by crop species was not consistent. This was due to a greater reduction in seeds per pod of cowpea in the flat-field planting treatment.

Seed yield

There were no significant differences in yield between field ridging and flat-field planting treatments. However, the higher average yield was obtained from flat-field planting treatment. In this experiment, the number of pods per plant and seeds per pod were slightly lower in flat-field planting due to the plants suffering from waterlogging during the growing period which resulted in low yield. Reduction in growth and yield of mungbean, cowpea and soybean were reported by Polthanee (1989); Takele and McDavid (1994) and Scott *et al.* (1989). Irrespective of crop species, there was a significant

Table 3 Tap root length and root dry weight of 3 legumes at harvest as influenced by ridge and flat-field planting treatments in the pre-monsoon season of Northeastern Thailand.

Treatments	Tap root length (cm)	Root dry weight (g/plant)
Drainage (D)		
Ridge (D1)	24.3	3.9
Flat (D2)	20.8	2.8
Crop species (C)		
Mungbean (C1)	23.4b	3.4ab
Cowpea (C2)	25.9a	3.7a
Soybean (C3)	18.4c	3.0b
Drainage x Crop species		
D1C1	25.3	4.1d
D1C2	27.4	4.2d
D1C3	20.3	3.3e
D2C1	21.5	2.6f
D2C2	24.6	3.2e
D2C3	16.3	2.7f
Drainage (D)	NS	NS
Crop species (C)	*	*
DXC	NS	*

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

difference in seed yields of mungbean, cowpea and soybean. The maximum seed yield was obtained with cowpea at 1903 kg/ha, while soybean and mungbean gave seed yields of 1679 and 1022 kg/ha, respectively (Table 4). There was an interaction effect for drainage method and crop species on the seed yields, indicating that the response to drainage method by crop species was not consistent. This was mainly due to less reduction of soybean yields planted in the flat-field planting treatment.

Economic return

Drainage methods did not significantly affect the net return. However, the flat-field planting gave slightly higher net return of 3,209 baht/ha over the ridge treatment (Table 5). This was mainly due to high labour cost for ridge construction. There was a significant difference in net return of mungbean, cowpea and soybean. Soybean gave the maximum average net return of 11622 baht/ha (Table 5). There was an interaction effect for drainage methods and crop species on the net return. This was due to less reduction on the net return of mungbean planted in the ridge treatment (Table 5).

CONCLUSION

Construction of ridges for water drainage did not significantly affect seed yield per unit of land area of the 3 legumes, althought the yield components and seed yields per plant were slightly higher in ridge treatment. This was attributed to

Table 4 Seed yields and yield components of 3 legumes as influenced by ridge and flat-field planting treatments in the pre-monsoon season of Northeastern Thailand.

Treatments	Pods/plant	Seeds/pod	100-seed weight (g)	Seed yield (kg/ha)
Drainage (D)				
Ridge (D1)	22.6	6.5	13.7	1523.4
Flat (D2)	16.2	5.6	13.4	1545.8
Crop species (C)				
Mungbean (C1)	13.2b	8.0a	6.1b	1022.0c
Cowpea (C2)	10.2b	8.2a	18.9a	1902.8a
Soybean (C3)	34.8a	2.1b	15.8a	1679.2b
Drainage x Crop species				
D1C1	16.2	8.4e	6.2	966.3h
D1C2	12.3	9.1d	19.1	1843.0e
D1C3	39.4	2.2g	15.8	1649.7f
D2C1	10.2	7.6f	5.9	1077.7g
D2C2	8.1	7.3f	18.7	1962.7d
D2C3	30.3	1.9g	15.7	1708.7f
Drainage (D)	NS	NS	NS	NS
Crop species (C)	**	*	**	**
DXC	NS	*	NS	*

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

ridge cultivation in which some part of the land was devoted to making furrows between ridges, thus reducing the optimum plant population per unit of land areas. Therefore, the flat-field planting gave slightly greater average seed yields per unit of land area than that of ridge cultivation. In economic terms, the flat-field planting gave higher net return than that of ridge cultivation due to labour cost for ridge construction. Comparing crop species, soybean gave the maximum net return of 15887 baht/ha with flat-field planting.

LITERATRE CITED

Gumbs, F.A. and J.I. Lindsay. 1993. Effect of soil water and tillage on cowpea *(Vigna unguiculata* L.*)* growth and yield on a clay soil. Trop. Agric. 70(1) : 27-32.

Herera, W.T. and H.G. Zandstra. 1979. The response of some major upland crops to excessive soil moisture. Paper presented at the 10 th Annual Scientific Meeting of the Crop Science Societies of the Philippines on April 23-25, 1979 at the University of the Philippines at Los Banos, Laguna.

KKU-FORD. 1978. Cropping Systems Project, Annual Report. Faculty of Agriculture, Khon Kaen University, Khon Kaen. 124 p.

Polthanee, A. 1989. Field-level drainage requirement of pre-rice mungbean crop in waterlogged – prone environment. Ph.D. Thesis, University of the Philippines at Los Banos.

Table 5 Net return (baht/ha) of 3 legumes as influenced by ridge and flat-field planting treatments in the pre-monsoon season of Northeastern Thailand.

Treatments	Net return (baht/ha)
Drainage (D)	
Ridge (D1)	7,484
Flat (D2)	10,693
Crop species (C)	
Mungbean (C1)	5,352b
Cowpea (C2)	10,291a
Sogbean (C3)	11,622a
Drainage x Crop species	
D1C1	5,111h
D1C2	9,502f
D1C3	7,358g
D2C1	5,592h
D2C2	11,080ef
D2C3	15,887d
Drainage (D)	NS
Crop species (C)	**
DXC	*

Values in the same column followed by the same letter are not significantly different at the 0.05 level.
Note : mungbean, cowpea and soybean price = 10, 8 and 12 baht/kg, respectively.
Material costs : seed, chemical fertilizer, dolomite and insecticides
Labour costs : land preparation and ridge construction

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. 79, Canberra.

Sallam, A. and H.D. Scott. 1987. Effects of prolonged flooding on soybeans during early vegetative growth. Soil Science 144 (1) : 61-66.

Scott, H.D. DeAngulo, J. Daniels, M.B., and L.S. Wood. 1989. Flood duration effects on soybean growth and yield. Agron. J. 81 : 631-636.

Takele, A. and C.R. McDavid. 1994. Effects of short-term waterlogging on cultivars of cowpea (*Vigna unguiculata L.*). Trop. Agric. 71 (1) : 275-280.

Zandstra, H.G. 1982. Effects of soil moisture and texture on the growth of upland crops after wetland rice, pp. 44-54. *In* Cropping Systems Research in Asia. IRRI, Los Banos.

Received date : 22/02/01
Accepted date : 30/03/01