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Influence of mulching on production potential and economic of rainfed rice based cropping system in foot hills of Manipur

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Abstract
Field experiments was conducted in foot hills of Ngarumphung, Ukhrul district during the kharif 2017 and rabi season of 2017-18 to study the influence of mulching on production potential and economics of rainfed rice-based cropping in foot hills of Manipur. Seven rice-based cropping system with and without mulching practice during rabi season were carried out. The findings indicated better conservation of residual soil moisture with straw mulching during the rabi season which resulted in increased yield of the rabi crops and was more pronounced in oat and field pea. Maximum rice equivalent yield was associated with rice – broad bean followed by rice field pea with mulching practice. Rice – lathyrus and rice – wheat sequence used the land for more periods in a year having land use efficiency of 72.33% and 71.78% respectively. The maximum production efficiency was recorded in rice – oat sequence (175.22kg/ha/day) followed by rice – field pea (30.14 kg/ha/day) with mulching. Among the cropping sequence rice- broad bean was found to be most remunerative with higher gross income, net income and benefit cost ratio followed by rice – pea with mulching under rainfed condition of Manipur.

Keywords: Cropping sequence, mulching, soil moisture, system productivity, production efficiency, economics

Introduction
In spite of the large cultivable area in the state the production of food cannot meet the demand of the increasing population in Manipur. This goal can be achieved if the available land is intensively cropped by utilizing the available resources more efficiently. The state is blessed with abundant solar radiation, moderate temperature and abundant rainfall. Hence, there is a need for proper management of these resources to boost the productivity of crops per unit area and time.

With the availability of high yielding varieties and improved management practices, the emphasis has shifted from yield stability of crop mixture to achievement of yield advantage, maintenance of soil fertility, increasing farm income and efficient utilization of resources through intensive cropping.

In agriculture, management practices are developed for individual crops and recommendations are made for them. The residual effects of individual crops are not considered in crop-based recommendation. In this approach, resources are not utilized efficiently. System approach is applied for efficient utilization of all resources, maintaining stability in production and obtaining higher net returns.

Rice is the most important cereal crop among the farmers of the Manipur during the kharif season entirely depending on the south west monsoon for water. Weather during the rest of the year remains dry where rabi crops are grown in sequence with rice. Due to limited irrigation facility in the state, the residual moisture of the monsoon is to be accounted for the success of the rabi crop. The success of the rabi crop again is also dependent on the tolerance of the crop to moisture stress. Another management aspect could be through conservation of the residual moisture through mulching with readily available crop residues at the farmer's level. As the information on these aspects is lacking in the state, hence the present investigation was undertaken.

Materials and Methods
Field experiments were under taken during kharif 2017 and rabi season of 2017 - 18 at farmer's field, Ngarumphung, Ukhrul district, Manipur." The experimental site is situated at

24.85°N latitude and 93.94°E longitude of 790 MSL. The climatic condition of Ngarumphung located at foot hills of Ukhrul is sub-tropical where the monsoon normally begins from June and extends up to September and withdraws from October onward. The soil of the experimental site was acidic with pH of 5.6, high in organic carbon (1.05%), medium in available N (320 kg/ha), P_2O_5 (29 kg/ha) and K_2O (277 kg/ha). The field capacity and bulk density of the soil was 30.5% and 1.52 g/cm^3 respectively. The total rainfall of 289.20 mm was recorded during the rabi experimentation and spread in 32 rainy days. The experiment was laid out in split plot design with three replications during the rabi season. The treatment comprises of seven cropping sequence (*viz*. rice – pea, rice – rapeseed mustard, rice – broad bean, rice – lathyrus, rice – lentil, rice – wheat and rice – oat) and two mulching practices (*viz*. no mulching and mulching with rice straw at 7.5 q/ha). The rice variety used in the experiment was CAU R1 (Tamphaphou). In the rabi season the varieties used were HUDP 15 (Pea), NRCHB 101 (rapeseed), Bio-L-212 (Lathyrus), PL 4 (Lentil), Kent (Oat), WH 1142 (Wheat) and Local (Broadbean). The kharif crop was sown on the 20th June, 2017 and the rabi crop on 9th November, 2017. All standard agro-techniques were followed during the experimentation.

The yield of grain/fodder and straw/stover of each crop was recorded during the kharif and rabi seasons (both with and without mulching). To compare the different cropping sequences, the yield of each crop was converted into rice equivalent on the price basis. The duration of each crop was recorded to work out the total duration of the system. Production efficiency values in terms of kg/ha/day were calculated by total production of crop in the rotation. Land use efficiency was worked out by taking total duration of crop in individual crop rotation divided by 365 days. The production efficiency values in terms of Rs/ha/day were calculated by net monetary returns of the rotation divided by total duration of the crop in that sequence. The Gross income, Net income and B:C ratio were worked out based on the existing price of the commodity in the local market. Soil moisture content (%) was calculated based on the thermo gravimetric method. The calculation for different parameters was worked out as per the given formula.

Production efficiency (kg/ha/day) = total production in a crop rotation divided by total duration of crop in that rotation.

Land use efficiency= total duration of crop in the individual crop rotation divided by 365 days.

Total production efficiency (Rs/ha/day) = net monetary returns of the rotation divided by total duration of the crop in that rotation

$$\text{Crop equivalent yield} = \frac{\text{yield (q/ha) of crop 'b' x price of crop 'b' (Rs/q)}}{\text{Price of crop 'a' (Rs/q) into which CEY is to be converted}}$$

All the data obtained were statistically analysed by the method of analysis of variance to test the significance of treatment effects as well as result interpretation as given Gomez and Gomez (1984) [4].

Results and Discussion

Soil moisture: The soil moisture status recorded at 20 days intervals from sowing of the rabi crops indicated that higher soil moisture percentage were recorded where mulching with paddy straw at 7.5q/ha was done as compared to no mulch irrespective of the crops (Table 1). Chakraborty *et al.* (2008) [3], Saha and Ghosh (2010) [8], Ram *et al.* (2013) [7] also report that organic mulching significantly increased soil moisture content in all the crop combinations. The soil moisture content values remained almost the same from first to third sampling, with slight increase in the fourth sampling and then decline with the approach of crop maturity irrespective of crops and mulching practice. The higher moisture content in soil at fourth sampling may be attributed to the rainfall received during that period.

Table 1: Soil moisture content (%) at 20 days interval as influenced by mulching in paddy-*rabi* crops sequence.

Crop	I sampling		II sampling		III sampling		IV sampling		V sampling		VI sampling	
	Without mulch	With Mulch	Without mulch	With Mulch	Without mulch	With Mulch	Without mulch	With Mulch	Without mulch	With Mulch	Without mulch	With Mulch
Wheat	19.11	20.72	18.49	20.48	19.35	20.47	21.53	22.18	17.99	19.48	17.60	20.14
Oat	18.11	20.20	17.91	19.85	18.22	20.20	21.34	23.79	-	-	-	-
Lentil	19.95	22.51	20.30	22.51	19.52	22.38	23.89	25.60	23.00	24.57	18.81	20.31
Field pea	19.81	21.11	19.79	21.31	20.35	21.67	22.28	25.04	20.74	22.17	18.51	20.54
Lathyrus	19.42	20.33	19.79	21.70	20.40	21.31	23.03	25.24	20.89	22.13	18.47	20.28
Broad bean	19.76	21.44	19.41	20.22	19.76	21.16	24.64	26.51	22.95	24.37	18.38	20.15
Rape seed	18.98	20.45	19.93	21.42	19.12	20.58	24.77	27.26	21.82	24.82	19.90	20.91

Note: Initial soil moisture content: 26.9%.

Grain yield

A perusal of Table 2 reveals that irrespective of the crops raised during the rabi season, the grain and straw/stover yield recorded higher with straw mulching practice at 7.5 q/ha over no mulching. Banik and Sharma (2008) [2], Kaur and Mahal (2017) [5] and Keshav *et al*., (2017) [6] also reported significant increase of grain or seed yield of winter crops with paddy straw mulching compared to no mulching. However, the variation was found to be significant only in rice- oat and rice- field pea system. This may be attributed to better conservation of soil moisture with mulching which resulted in better growth and development of the crop. The percentage of yield increase with mulching over no mulching for different crops ranges from 4.84 to 17.60. The highest being recorded in rapeseed (17.6%) followed by broad bean (14.70%) and pea (13.93%) respectively.

Table 2: Grain/fodder yield (q/ha) of crops and rice equivalent yield as influence by mulching

Crops	Grain Yield (q/ha)		Stover Yield (q/ha)		Rice equivalent yield (q/ha)	
	Without mulch	With mulch	Without mulch	With mulch	Without mulch	With mulch
Rice-Wheat	28.4	31.0	43.7	47.3	29.4	32.1
Rice- Oat	310.0	325.0	-	-	42.2	44.2
Rice-Lentil	17.2	18.1	40.7	44.3	39.2	45.0
Rice-Field pea	19.1	22.9	48.3	52.0	55.2	66.1
Rice-Lathyrus	3.9	4.1	12.3	16.0	40.0	41.8
Rice-Broadbean	10.2	11.7	18.7	22.3	118.4	135.0
Rice-Rape seed	10.9	14.0	23.0	26.7	24.8	31.8
Rice	55.2		67.79		-	-
S.Em+ (Crops)	2.41				3.19	
C.D. (0.05)	6.92				9.02	
S.Em+ (Muching)	1.29				1.71	
C.D. (0.05)	3.74				4.96	
Interaction (Mulch x Crops)						
S.Em+ (MxC)	3.41				4.51	
C.D.(0.05)	NS				NS	

System productivity

On the basis of rice equivalent yield, significantly highest yield (135 q/ha) was associated with rice – broad bean sequence. This was followed by rice- field pea (66.10 q/ha) which showed significant superiority over the other cropping sequence. However, rice – lentil (45.0q/ha), rice – oat (44.2 q/ha) and rice – lathyrus (41.8 q/ha) remained at par to each other in respect on rice equivalent yield. Similar trends were also observed in rice equivalent yield of different cropping sequence where no mulching was done. Again, mulching practice showed significant superiority in rice equivalent yield in rice – lentil, rice –field pea, rice – broad bean and rice – rapeseed over no mulching. Mulching has proved to be useful in conserving moisture and increasing productivity of crops (Ahmed *et al*., 2007 [1]; Chakraborty *et al*., 2008 [3]; Ram *et al*., 2013 [7]; WeiSu *et al*., 2014 [9]). However, in the other cropping sequence (rice – wheat, rice – oat and rice - lathyrus) the rice equivalent yield with mulching did not significantly differ with that of no mulch. The higher rice equivalent yield may be attributed to more efficient utilization of the conserved moisture by mulching resulting in better growth and increased yield of the crop and higher selling price of the produce. The interaction between the system and mulching could not show any significant variation in respect of rice equivalent yield.

The variation in the duration of the system was recorded for the different cropping sequence. The rice- lathyrus exhibited the longest duration of 264 days which was closely followed by rice – wheat (262 days) and rice – field pea and rice – rapeseed (159 days).

Land use efficiency and production efficiency

Rice – lathyrus cropping sequence used the land for more periods in a year having land use efficiency of 72.33% and was followed by Rice – wheat (71.78%). However, the other cropping sequences like rice- rapeseed, rice – lentil, rice- field pea and rice – broad bean used the land for 69.58 to 70.96% period of the year (Table 3). The lowest land use efficiency was observed in rice- oat sequence (59.45%). The variation in land use efficiency was primarily due to the difference in the duration of the rabi crops in the cropping sequence.

In general, the maximum production efficiency was recorded when fodder crop like oat was included in the system (rice – oat i.e., 175.22 kg/ha/day) as compared to other cereals, pulses and oil seed crop under consideration. Among the pulses (lathyrus, broad bean, lentil and field pea) included in the sequence during the rabi season, rice – field pea obtained the highest production efficiency recording 30.14 kg/ha/day (Table 3). In all the cropping sequence, mulching practice with paddy straw at 7.5 q/ha showed higher production efficiency than no mulch. The differences in the production efficiency of the cropping system may be attributed to the variation in the duration of the rabi crops with oat having the shortest days to harvest.

Table 3: Crop duration, land use efficiency and production efficiency of different rice-based cropping systems as influenced by mulching

Crop	Duration of the system (days)	Land use efficiency (%)	Production efficiency (Kg/ha/day)	
			Without mulch	With Mulch
Rice-Wheat	262	71.78	31.92	32.92
Rice-Oat	217	59.45	168.31	175.22
Rice-Lentil	257	70.41	28.19	28.53
Rice-Field pea	259	70.96	28.7	30.14
Rice-Lathyrus	264	72.33	22.41	22.48
Rice-Broadbean	254	69.58	25.75	26.34
Rice-Rape seed	259	70.96	25.54	26.72
Rice	132	-		

Economic analysis

All the economic indices i.e. Gross return, net return and benefit cost ratio were recorded higher with mulching practice as compared to without mulch in the rabi crops for all the cropping sequence considered (Table 4). Kaur and Mahal (2017) [5] showed that the gross returns were significantly higher where mulch was applied than no mulch application. Among the seven cropping sequences, rice – broad bean recorded the highest gross income (Rs 336486, 255283), net income (Rs 262612, 182629) and benefit cost ratio (Rs 4.55:1,

3.51:1) with and without mulch. The higher profit of the system may be attributed to more selling price of the produce with reasonably high yield of broad bean. The next higher income could be obtained from rice – field pea cropping sequence. The least income generating system could be observed in rice – wheat sequence without mulching in the rabi crop. Further, production efficiency in terms of Rs/ha/ day was recorded maximum in rice – broad sequence (Rs 1033.9 & 719.0), followed by rice – field pea (Rs 418.50 & 360.5) and rice – oat (Rs 362.1 & 353.9) with and without mulching practices.

Table 4: Economics of different rice-based cropping systems as influenced by mulching

Crop	Cost of Cultivation for system		Gross Returns for system (Rs./ha)		Net Returns for system (Rs./ha)	B:C ratio of the system			Total Production efficiency (Rs./ha/day)	
	Without mulch	With Mulch	Without mulch	With Mulch	Without mulch	Without mulch	Without mulch	With Mulch	Without mulch	With Mulch
Rice-Wheat	71315	72535	124462	128427	53147	55892	1.75	1.77	202.9	213.3
Rice-Oat	66412	67632	143203	146203	76791	78571	2.16	2.16	353.9	362.1
Rice-Lentil	68635	69855	138823	141771	70188	71916	2.02	2.03	273.1	279.8
Rice-Field pea	70807	72027	162378	178315	91571	106289	2.29	2.48	360.5	418.50
Rice-Lathyrus	70424	71644	140003	142703	69578	71058	1.99	1.99	263.6	269.2
Rice-Broadbean	72653	73873	255283	336486	182629	262612	3.51	4.55	719.0	1033.9
Rice-Rape seed	61430	62650	117718	127969	56288	65319	1.92	2.04	217.3	252.2
Rice	40447	-	81203	-	40756	-	2.01	-	308.8	-

Conclusion

From the present investigation it can be concluded that better conservation of residual soil moisture with straw mulching was observed during the rabi season which resulted in increased yield of the crops irrespective of the cropping sequence. Higher gross income, net income and benefit cost ratio were recorded with mulching practice in the rabi crops for all the cropping sequence considered. The highest system productivity and economic indices were associated with rice-broad bean sequence.

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