Effectiveness of Crop Residues Mulching on Water Use Efficiency and Productivity under Different Annual Cropping Patterns of Magway

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Abstract

Water availability in dryland crop production is influenced by the quantity of rainfall and soil ability for holding it. To improve dryland agricultural productivity, understanding of crop water use through the growing season as affected by different residue management is necessary. Two- consecutive seasons field experiments (monsoon and postmonsoon seasons of 2015-2016) were conducted at the Oilseed Crop Research Center, Magway. The experimental design was RCB factorial arrangements with three replications. Crop residue mulching at the rate of 5 t ha^{-1} (M) and non-mulching (NM) were tested with five levels of cropping patterns: sesame-green gram (SS-GG), sesame-groundnut (SS-GN), groundnut-green gram (GN-GG), groundnut-groundnut (GN-GN) and groundnut-sorghum (GN-SG). The objectives of the present study were to determine the grain yield and biomass production and water use efficiency of individual crops in the cropping patterns; and to investigate appropriate cropping sequences for better harvested monetary benefit per unit rainfall under rainfed condition. Crop residue mulching proved its potential to improve crop production through crop yield, biomass production and WUE in both seasons. High profit and the best harvested monetary benefit were obtained using crop residue mulching. Among the postmonsoon season crops, green gram was short duration crop and capable to produce optimal yield with limited amount of soil moisture under unfavorable weather condition. The groundnut crop in GN-GN with mulching gave the highest yield, biomass, WUE and harvested monetary benefit in monsoon seasons. The green gram in SS-GG and GN-GG with mulching and groundnut in SS-GN with mulching gave higher yield and WUE in postmonsoon seasons among all cropping patterns. Therefore, crop residue mulching should be practiced to protect soil deterioration and improve soil water in sandy soil and eventually sustain agricultural productivity.

Key works: crop residue mulching, dryland cropping pattern, water use efficiency and harvested monetary benefit

Introduction

Soil water management is a critical component in agricultural production systems for optimization of grain yields. Soil water is essential for mineral weathering and organic matter decay, chemical reactions that provide soluble nutrients in the plant-soil system. Water also serves as the medium in which nutrients move to the plant roots.

The majority of the farmers in central dry zone in Myanmar rely mainly on rainfed crop production systems, and lack incentive to improve water use efficiency in agricultural production and motivation to conserve water during the growing period. In rainfed agricultural systems, soil water infiltration and storage in the root zone determine the overall availability and water use efficiency in crop production (Hsiao et al. 2007). Therefore, planning agricultural systems that are efficient users of available water, as a prerequisite for improving water productivity, requires a good understanding of crop water use. (Mulebeke et al. 2010).

Sharma et al. (2010) observed that crop residue mulching is very beneficial for enhancing moisture and nutrient conservation, resulting in increased productivity and improved soil conditions for the maize-wheat cropping system. Kolawole et al. (2004) observed that maize yield increased by 47% on mulching of *Pueraria* residues compared to non-residue application. Lamers and Bruentrup (1996)

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studied the use of crop residue and found that the highest gross marginal returns for land was from the mulching with crop residues.

Studies with annual cropping systems have generally confirmed improvements in soil moisture, water use efficiency, crop yield and economic benefit with conservation agriculture. A successful crop rotation system is not only a profitable agricultural system but also a beneficial soil conservation tool. Low soil fertility, ineffective water use practices and lack of scientific based rotations for crop water use contribute to the sub-optimal yield of crops (Safdar et al. 2002). The rainfed environment for agriculture is extremely fragile and has limitations for soils, water and crop management. This paper presented a detailed study on the amount of water use and yield for some cropping patterns with or without crop residue mulching in a semi-arid environment. The purposes of this study were to (1) determine the grain yield and biomass production and water use efficiency of individual crop in the cropping patterns; and (2) investigate appropriate cropping sequences for harvested monetary benefit per unit rainfall under rainfed condition.

Materials and Methods

Experimental sites: The study was conducted on a rainfed dryland at Oilseed Crop Research Center in Magway (20˚ 16´ N, 94˚ 93´ E, elevation of 82 meters above sea level) in the central dry zone of Myanmar. The experiments were conducted during monsoon and postmonsoon season of 2014-2015 to 2015-2016. The soil type is a well-drained sandy soil with pH is 7.42. The soil texture was sandy and it contained 92.8%, 4.16% and 3.04% of sand, silt and clay in texture, respectively. The average bulk density is 1.6 g cm^{-3}.

Experimental design and treatments: Four principal crops were chosen as rotation crops, namely, sesame, groundnut, green gram and sorghum. According to the cropping patterns selected by survey, sesame and groundnut were grown as monsoon crop while groundnut, green gram and sorghum were cultivated as postmonsoon crop. The experimental design was RCB factorial arrangements with three replications. Crop residue mulching at the rate of 5 t ha^{-1} (M) and non-mulching (NM) were tested with five levels of cropping patterns - sesame-green gram (SS-GG), sesame-groundnut (SS-GN), groundnut-green gram (GN-GG), groundnut-groundnut (GN-GN), groundnut-sorghum (GN-SG). The previous season crop residues were chopped to pieces and then mulched to the individual plot at one week after sowing. The individual plot size was 8 m x 10 m, and 3.3 m x 3.3 m space at the middle of plot was conserved for yield and biomass measurement. The sowing and harvesting dates of different crops in two growing seasons are presented in Table 1.

Water use and water use efficiency: Water use efficiency (WUE) can be defined in different ways and in this experiment, the agronomic or crop WUE has been used, which is defined as the amount of yield or biomass produced per unit volume of water evapotranspiration (Fuentes et al. 2003). Water use efficiency (WUE) of each crop grown for grain and biomass purpose in different spatial cropping sequences was calculated by using the formula given by Gregory (1991).

$$\mathrm{WUE} = \frac{\mathrm{e}}{\mathrm{f} - \mathrm{g} + \mathrm{h}}$$

Where "e" is the grain yield (or) above ground

Table 1. The sowing and harvesting dates of different crops during growing season.

Cropping Sequence	Monsoon Season		Postmonsoon Season	
	Sowing date	Harvesting date	Sowing date	Harvesting date
Sesame-green gram	26.5.2015	29.8.2015	30.8.2015	5.11.2015
Sesame- groundnut	26.5.2015	29.8.2015	30.8.2015	3.12.2015
Groundnut-green gram	21.6.2015	7.10.2015	8.10.2015	17.12.2015
Groundnut-groundnut	21.6.2015	7.10.2015	8.10.2015	14.1.2015
Groundnut-sorghum	21.6.2015	7.10.2015	8.10.2015	23.1.2015

biomass yield (kg ha^{-1}), "f" and "g" are soil water contents (mm) measured at planting and at harvest, respectively and h is precipitation during crop growing season. The soil moisture content was determined from 0-1.5 m soil depth at the time of sowing and harvest for each crop in each cropping sequence.

Harvested monetary benefit: The harvested monetary benefit (HMB) of different cropping sequences per unit of rainfall was worked out for efficient utilization of available rainfall water i.e., how many kyats can be earned from one millimeter (mm) of rainfall by a specific cropping sequence. It was calculated by applying the methodology described by CIMMYT (1988) and Arif et al. (2009) using the following formula.

$$\text{Harvested Monetary Benefit (HMB)} = \frac{\text{NetReturn (Kyats.ha}^{-1})}{\text{Rainfall (mm)}}$$

Crop data: Grain yield and total dry matter were recorded at maturity on the area of (3.3 x 3.3) m^2 from the center part of each plot. When stem, leaf and stover (for sorghum) were harvested, these were sun-dried to a constant weight for 2-3 weeks.

Statistical analysis

ANOVA was used to assess treatment effects on the measured variables and differences between mean values were compared using the LSD (0.05) level. Statistix 8 program was used for all of the statistical analyses. Simple linear correlation and regression analysis was used to determine between evapotranspiration, crop yield and dry matter.

Climatic Condition

Amount of total rainfall in 2015 was 927.3 mm. In this rainfed area, 89.8% of total rainfall (832.5 mm) was received during crop growing period and highest rain intensity occurred in July and October (Figure 1). Amount of rainfall in monsoon season was 767.5 mm and 115.1 mm in postmonsoon season. The rainfall in October (first week) (266.7 mm), towards the more usual end of the monsoon season, is an important determinant of the amount of water stored in the soil.

Results and Discussion

Crop yield and biomass production

Crop residue mulching significantly ($P<0.05$) increased the grain and biomass yield of crops compared with non-mulching during 2015-2016 growing seasons (Table 2). Crop residue mulching gave significantly higher grain yield (1.45 t ha^{-1}) and biomass (4.37 t ha^{-1}) in monsoon season and grain yield (0.92 t ha^{-1}) and biomass (2.95 t ha^{-1}) in postmonsoon season than non-mulching. Crop yield of residue mulching treatment showed (27.6% for monsoon season and 17.4% for postmonsoon season) higher than non-mulching. This finding was similar to those of Adama Coulibaly et al. (2000) who reported surface residue mulching increased cowpea grain yield (25%) than residue removed in Mali. Yield increment in mulching system could be due to the presence of enough moisture to maintain increased microbial activity, nutrients mobility and favorable conditions for growth (Schonbeck and Evanylo 1998; Dahiya et al. 2007). The results revealed that mulching of crop residues resulted 1.3 and 1.1 times increase in biomass production compared with non-mulching treatment in monsoon season and postmonsoon season, respectively. The-

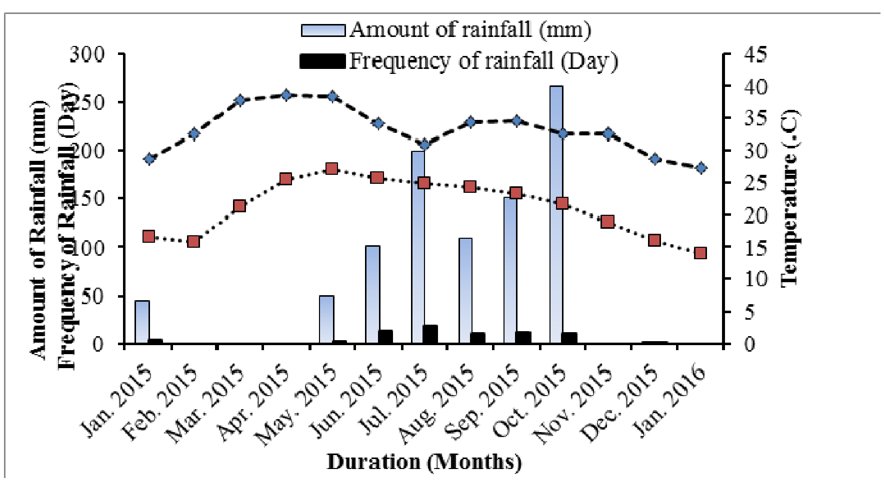

Figure 1. Monthly rainfall, average maximum and minimum temperature from January 2015 to January 2016.

se results were in agreement with the finding of Pandiaraj et al. (2015) who reported that the use of crop residue increased 1.4 times in the biomass production.

The yield and biomass as influenced by cropping patterns are given in Table 2. The highest crop yield (1.77 t ha^{-1}) and biomass (5.50 t ha^{-1}) were recorded in groundnut crop in GN-GN cropping pattern of monsoon season. The lowest yield (0.58 t ha^{-1}) and biomass (1.90 t ha^{-1}) was observed in sesame crop of SS-GG cropping pattern, where was statistically similar to the yield and biomass of groundnut or sesame found under same cropping patterns in monsoon season. In postmonsoon season, the effect of cropping pattern on crop yield and biomass production was found significantly. The lowest yield (0.39 t ha^{-1}) was observed in sorghum crop in GN-SG cropping pattern and the lowest biomass (1.75 t ha^{-1}) was recorded in the groundnut crop in GN-GN cropping pattern in postmonsoon season. The highest yield (1.49 t ha^{-1}) and biomass (4.05 t ha^{-1}) were observed in the groundnut crop in SS-GN cropping pattern. Postmonsoon crops in groundnut-based cropping pattern received 112 to 113.6 mm of rainfall while postmonsoon season crops in sesame-based cropping pattern received 418.3 mm of rainfall.

The interaction between crop residue mulching and cropping pattern on grain and biomass yield did not indicate significant differences in 2015 monsoon season, while significant differences were found in biomass production of postmonsoon season (Table 2). In all of cropping patterns, crop residue mulching gave higher yield than non-mulching in both seasons except in sorghum crop under GN-SG cropping pattern with mulching in the postmonsoon season. Crop yield is also affected by incidence of pests under high rates of residue retention (Mann et al. 2002). The residue mulching increased 11.4 to 48.8% the grain yield compared to non-mulching. These results agreed with Surekha et al. (2003) and Kouyate et al. (2000). Sorghum and groundnut crops should not be grown after harvest of groundnut. The postmonsoon season crops (green gram and groundnut) in sesame-based cropping pattern produced good biomass and grain yield than those crops in groundnut-based cropping pattern. After harvest of postmonsoon crop in groundnut based cropping pattern, the soil is very dry at upper layer of soil. Pod yield of groundnut was very influenced by the availability of soil moisture. SS-GG and GN-GG with crop residue mulching gave increasing yield.

Table 2. Yield and biomass production of different crops in the different cropping patterns as affected by crop residue mulching and non -mulching in monsoon and postmonsoon seasons, 2015-2016.

Treatment	Monsoon crop Biomass (t ha^{-1})	Monsoon crop Yield (t ha^{-1})	Postmonsoon crop Biomass (t ha^{-1})	Postmonsoon crop Yield (t ha^{-1})
Crop residue mulching				
Non-mulching	3.41 b	1.05 b	2.63 b	0.76 b
Mulching	4.37 a	1.45 a	2.95 a	0.92 a
$LSD_{0.05}$	**0.44**	**0.16**	**0.28**	**0.11**
Cropping pattern				
SS-GG	1.90 b	0.58 b	3.43 b	1.16 b
SS-GN	2.07 b	0.65 b	4.05 a	1.49 a
GN-GG	4.93 a	1.68 a	1.98 d	0.62 c
GN-GN	5.50 a	1.77 a	1.75 d	0.55 c
GN-SG	5.05 a	1.57 a	2.74 c	0.39 d
$LSD_{0.05}$	**0.69**	**0.26**	**0.44**	**0.18**
Pr>F				
CRM	<0.001	<0.001	0.027	0.008
CP	<0.001	<0.001	<0.001	<0.001
CRM × CP	0.611	0.733	0.004	0.226
CV%	**14.6**	**17.1**	**13.0**	**17.2**
CRM x CP				
NM×SS-GG	1.39	0. 41	3.16 b	1.08
NM×SS-GN	1.58	0.44	3.68 b	1.35
NM×GN-GG	4.55	1.50	1.62 d	0.51
NM×GN-GN	4.73	1.47	1.49 d	0.45
NM×GN-SG	4.80	1.43	3.20 b	0.42
M×SS-GG	2.40	0.75	3.70 b	1.23
M×SS-GN	2.56	0.86	4.41 a	1.63
M×GN-GG	5.32	1.86	2.33 c	0.74
M×GN-GN	6.27	2.07	2.00 dc	0.65
M×GN-SG	5.30	1.71	2.28 c	0.32

SS: sesame; GG: green gram; GN: groundnut; SG: sorghum; CRM: crop residue mulching; CP: cropping pattern

Seasonal water use and soil water depletion

Crop residue mulching and cropping pattern effect on water use and soil water depletion during the growing season are reported in Table 3. There was not statistically different in water use and soil water depletion among mulching and non-mulching in both seasons. The seasonal water use under mulching (477.9 mm in monsoon season and 339.0 mm in postmonsoon season) was little higher that under non-mulching (466.0 mm in monsoon season and 336.9 mm in postmonsoon season), respectively. Similar result was also reported by Mesfine et al. (2005) in Ethiopia and they observed that higher seasonal water use was occurred in mulching treat-

Table 3. Water use and soil water depletion of different crops in the different cropping patterns as affected by crop residue mulching and non -mulching in monsoon and postmonsoon seasons, 2015-2016.

Treatment	Monsoon crop		Postmonsoon crop		TWU (mm)
	SWD (mm)	WU (mm)	SWD (mm)	WU (mm)	
Crop residue mulching					
Non-mulching	-103.2	466.0	101.8	336.9	802.9
Mulching	-91.3	477.9	103.9	339.0	816.9
$LSD_{0.05}$	**14.9**	**14.9**	**10.1**	**10.1**	**18.5**
Cropping pattern					
SS-GG	-92.3 ab	297.5 b	56.3 c	474.6 b	772.1 b
SS-GN	-81.7 b	308.1 b	109.8 b	528.1 a	836.1 a
GN-GG	-110.9 a	577.8 a	127.9 a	239.9 c	817.7 a
GN-GN	-94.2 ab	594.5 a	115.1 ab	228.7 cd	823.2 a
GN-SG	-107.1 a	581.6 a	105.0 b	218.6 d	800.2 ab
$LSD_{0.05}$	**23.6**	**33.4**	**15.9**	**15.9**	**29.3**
Pr>F					
CRM	0.108	0.108	0.668	0.668	0.126
CP	<0.001	<0.001	<0.001	<0.001	0.002
CRM × CP	0.965	0.965	0.349	0.349	0.774
CV%	**20.0**	**4.1**	**12.8**	**3.9**	**3.0**

SS: sesame; GG: green gram; GN: groundnut; SG: sorghum; SWD: soil water depletion; WU: water use; TWU: total water use; CRM: crop residue mulching; CP: cropping pattern

ment as compared to no mulch treatment. Soil water depletion under mulching was little higher than that of non-mulching. This is due to the poor performance of the crops under non-mulching resulting from unfavorable weather condition. Growth and yield of crops under mulch management were higher with evapotranspiration.

It was significantly different in water use and soil water depletion among cropping patterns in both seasons (Table 3). In the monsoon season, sesame crop received 389.8 mm of rainfall while groundnut received 688.7 mm of rainfall. Water use varied from 297.5 to 594.5 mm in monsoon season. Groundnut crop received 266.7 mm of rainfall before harvest time. Therefore, soil water depletion of groundnut was lesser than sesame. In the postmonsoon season, water use varied from 218.6 to 528.1 mm. The highest seasonal water use was occurred in SS-GG and SS-GN cropping patterns. Groundnut and green gram crops after sesame were received higher amount of rain than postmonsoon crops after groundnut. Fuentes et al. (2003) found that depletion of soil water storage coincided with maximal plant growth during tillering and harvesting of wheat crop. The lowest soil water depletion value (56.3 mm) was observed in SS-GG cropping pattern. Green gram is short duration crop and this crop was harvested before depletion of soil moisture. Among the cropping patterns, the highest mean total water use (836.1 mm) was observed in SS-GN cropping pattern during 2015 growing season. There was no interaction effect between mulching and cropping pattern in table (3).

Water use efficiency

The results showed that WUE of grain and biomass of crop residue mulching treatment were significantly higher than that of non-mulching in Table 4. WUE increased with increasing yields. Highest

Table 4 Water use efficiency of different crops in the different cropping patterns as affected by crop residue mulching and non-mulching in monsoon and postmonsoon seasons, 2015-2016.

Treatment	Monsoon crop		Postmonsoon crop	
	WUE of Yield (kg ha^{-1} mm^{-1})	WUE of Biomass (kg ha^{-1} mm^{-1})	WUE of Yield (kg ha^{-1} mm^{-1})	WUE of Biomass (kg ha^{-1} mm^{-1})
Crop residue mulching				
Non-mulching	2.11 b	6.90 b	2.16 b	8.26
Mulching	2.96 a	8.96 a	2.60 a	9.02
$LSD_{0.05}$	**0.28**	**0.81**	**0.30**	**0.96**
Cropping pattern				
SS-GG	1.95 b	6.39 b	2.44 a	7.24 b
SS-GN	2.10 b	6.72 b	2.82 a	7.66 b
GN-GG	2.91 a	8.54 a	2.59 a	8.24 b
GN-GN	2.99 a	9.29 a	2.37 a	7.58 b
GN-SG	2.71 a	8.70 a	1.68 b	12.49 a
$LSD_{0.05}$	**0.45**	**1.28**	**0.49**	**1.53**
Pr>F				
CRM	<0.001	<0.001	0.007	0.109
CP	<0.001	<0.001	0.002	<0.001
CRM × CP	0.228	0.184	0.138	0.007
CV%	**14.5**	**13.3**	**17.0**	**14.6**
CRM × CP				
NM × SS-GG	1.42	4.81	2.28	6.68 d
NM × SS-GN	1.45	5.25	2.57	7.00 d
NM × GN-GG	2.67	8.05	2.13	6.83 d
NM × GN-GN	2.50	8.03	2.00	6.69 d
NM × GN-SG	2.49	8.34	1.83	14.08 a
M × SS-GG	2.48	7.98	2.60	7.80 cd
M × SS-GN	2.74	8.19	3.08	8.31 cd
M × GN-GG	3.16	9.03	3.05	9.64 bc
$LSD_{0.05}$	**0.63**	**1.81**	**0.69**	**2.16**

SS: sesame; GG: green gram; GN: groundnut; SG: sorghum; NM: non-mulching; M: mulching; WUE: water use efficiency; CRM: crop residue mulching; CP: cropping pattern

WUE of yield (2.96 kg ha^{-1} mm^{-1}) and WUE of biomass (8.96 kg ha^{-1} mm^{-1}) in monsoon season and WUE of yield (2.60 kg ha^{-1} mm^{-1}) and WUE of biomass (9.02 kg ha^{-1} mm^{-1}) in postmonsoon were obtained from crop residue mulching. WUE of yield showed (28.7% for monsoon season and 16.9% for postmonsoon season) higher under crop residue mulching than non-mulching. WUE of biomass showed (23.0% for monsoon season and 8.4% for postmonsoon season) higher under crop residue mulching than non-mulching. Similar result was also reported by Liu et al. (2004) who showed an increase in WUE of 10.6% in corn production with residue cover soils as compared with no residue covered soil in North China Plain.

The effects of different cropping patterns on WUE of yield and biomass were found to be highly significant difference (Table 4). In monsoon season, yield and biomass WUE of groundnut based cropping patterns were higher than that of sesame based cropping patterns. This is due to the difference in yield and biomass production of sesame and groundnut crops. Moreover, sesame had lesser water use or evapotranspiration than groundnut. In postmonsoon season, there were not significant differences in WUE among most of cropping patterns, except GN-SG cropping patterns. The lowest yield WUE (1.68 kg ha^{-1} mm^{-1}) and the highest biomass WUE (12.49 kg ha^{-1} mm^{-1}) was observed in GN-SG cropping patterns. If the total water supply is same, WUE will only be increased if transpiration is increased proportionally (Sharma and Acharya 2000). This study has clearly demonstrated that the cultivation of groundnut in monsoon and green gram or groundnut in postmonsoon had greater water use efficiency than sesame or sorghum.

In monsoon season, there was no interaction effect between mulching and cropping pattern in Table 4. Among sesame-based cropping pattern, SS -GN -M gave highest grain and biomass water use efficiency (2.74 and 8.19 kg ha^{-1} mm^{-1}), respectively. Among groundnut-based cropping patterns, GN-GN -M gave the highest grain and biomass water use efficiency (3.48 and 10.54 kg ha^{-1} mm^{-1}), respectively. In postmonsoon season, the highest value of yield WUE (3.08 kg ha^{-1} mm^{-1}) was observed in SS-GN cropping pattern with mulching and the lowest grain WUE (1.54 and 1.83 kg ha^{-1} mm^{-1}) were observed in GN-SG -NM and GN-SG –M treatments. Therefore, sorghum should not be grown after harvesting of monsoon season groundnut crop for the grain production. This value can vary considerable in different years and at different locations (Cook and Veseth 1991). In Magway area, the variability in the amount and distribution of seasonal rainfall may be a major source of variation in evapotranspiration and WUE.

Harvested monetary benefit

Crop residue mulching gave significantly higher net monetary return (1078 thousand Kyats) and better harvested monetary benefit (1.34 thousand Kyats ha^{-1} mm^{-1}) than non-mulching (Table 5).

There were significantly different in net monetary return and harvested monetary benefit between cropping patterns (Table 5). The maximum profit

Table 5. Net monetary returns and harvested monetary benefit of different cropping patterns as affected by crop residue mulching and non-mulching in monsoon and postmonsoon seasons, 2015-2016.

Treatment	Income (Thousand Kyats ha^{-1})	Net monetary return (Thousand Kyat ha^{-1})	Harvested monetary benefit (Thousand Kyat ha^{-1} mm^{-1})
Crop residue mulching			
Non-mulching	1736 b	412 b	0.51 b
Mulching	2402 a	1078 a	1.34 a
$LSD_{0.05}$	**126**	**126**	**0.16**
Cropping pattern			
SS-GG	2526 a	1400 a	1.73 a
SS-GN	2506 a	1207 a	1.49 b
GN-GG	2058 b	682 b	0.85 c
GN-GN	1842 c	294 c	0.37 d
GN-SG	1413 d	143 c	0.18 d
$LSD_{0.05}$	**199**	**199**	**0.25**
Pr>F			
CRM	<0.001	<0.001	0.002
CP	<0.001	<0.001	0.002
CRM × CP	<0.001	<0.001	0.002
CV%	**7.9**	**22.0**	**22.1**
CRM × CP			
NM × SS-GG	2094 bc	968 b	1.20 b
NM × SS-GN	1959 cd	660 c	0.82 cd
NM × GN-GG	1779 de	404 cd	0.50 de
NM × GN-GN	1524 ef	-25 e	-0.03 f
NM × GN-SG	1325 ef	55 e	0.68 f
M × SS-GG	2959 a	1833 a	2.27 a
M × SS-GN	3053 a	1753 a	2.17 a
M × GN-GG	2336 b	961 b	1.20 bc
$LSD_{0.05}$	**282**	**282**	**0. 35**

SS: sesame; GG: green gram; GN: groundnut; SG: sorghum; CRM: crop residue mulching; CP: cropping pattern

(1400 thousand Kyats) and best harvested monetary benefit (1.73 thousand Kyats ha^{-1} mm^{-1}) was recorded from the SS-GG cropping pattern. The minimum profits were obtained from GN-GN and GN-SG cropping pattern. This is due to lower yield of groundnut and sorghum crops that cultivated at postmonsoon season. Yield reduction was showed by water stress condition during postmonsoon season, especially monsoon groundnut-based cropping sequence and consequently, net monetary return was negative.

In the present study, there was significantly different on the interaction effect of mulching with cropping patterns in net monetary return and harvested monetary benefit (Table 5). Net monetary return and harvested monetary benefit for all cropping system increased with crop residue mulching. The SS-GG and SS-GN proved to be the best cropping sequence with mulching that harvested thousand Kyats 2.27 and 2.17 per mm of rainfall, respectively, as compared to the rest of the treatments. The postmonsoon groundnut and sorghum after groundnut crops without mulching should not be adopted due to very poor growth and performance in terms of monetary benefit and efficient utilization of rainfall. Farroq and Basshir (2001) conclude that improved cropping patterns can harvest more economic returns without effecting soil moisture for succeeding crops.

Conclusion

In present studies, application of crop residue as mulching materials enhanced significantly in increasing the crop yield and biomass production in both seasons. High profit and best harvested monetary benefit were obtained using crop residue mulching. Soil surface conditions are major important in determining the water content of soil. Maximum evapotranspiration was occurred in moist soil. Therefore, growth and yield of crops under mulch management increased with evapotranspiration.

Among the cropping patterns, higher WUE of yield and harvested monetary benefit were occurred in SS-GG, GN-GG and SS-GN cropping patterns. But highest grain yield and biomass was observed in groundnut crop from groundnut-groundnut cropping pattern in monsoon season while green gram crop under sesame-green gram cropping pattern and groundnut crop under sesame-groundnut cropping pattern gave highest yield in postmonsoon season. Among the postmonsoon season crops, green gram was short duration crop and capable to produce optimal yield with limited amount of soil moisture under unfavorable weather condition. The postmonsoon groundnut and sorghum after groundnut crops without mulching should not be adopted due to very poor performance in terms of monetary benefit and efficient utilization of rainfall under low rainfall condition.

The groundnut crop in GN-GN with mulching gave the highest yield, biomass, WUE and harvested monetary benefit in monsoon season. The green gram crop in SS-GG and GN-GG with mulching and groundnut crop in SS-GN with mulching gave highest yield and WUE in postmonsoon season. Moreover, application of crop residues to the field is a part of the implementation of conservation agriculture technologies under rainfed dryland production system. Therefore, crop residue mulching should be practiced to protect soil deterioration and improve soil water in sandy soil and eventually sustain agricultural productivity.

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