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WHEAT CROP PRODUCTIVITY IN THE MUNGBEAN – WHEAT CROPPING SYSTEM IN RAINFED AREA OF POTOHAR PAKISTAN

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ABSTRACT

Crop rotations have always a vital role in balancing of inter crops nutritional management, inhibiting of soil degradation, reduction of biotic and a biotic stress and in adapting to climate change. Potohar region is divided into three distinct rainfall zones i.e. high rainfall (>750 mm of annual rainfall), medium (500 to 750 mm) and low rainfall (<500 mm). Wheat is main rabi season crop of this region, while during kharif season groundnut, maize and sorghum are mostly planted in some areas, however maximum area is kept fallow and farmers plough it up for a number of times to conserve rain water for the planting of wheat crop. During two different crop seasons (2014-15 and 2016-17), adaptation plots of Mungbean-Wheat cropping system in comparison with Fallow-Wheat cropping system were planted on five different farmer's fields, in the medium and high rainfall zones of this region. During both years yields of both Mungbean and wheat crop varied from field to field, especially due to rainfalls timings and their quantities, soil conditions, cropping systems and crop management etc. During cropping seasons 2014-15 and 2016-17, wheat crop grain yields were recorded 3.80 t/ha and 2.92 t/ha respectively in Mungbean - Wheat cropping system as compared with Fallow-Wheat cropping system having yields of 3.15 t/ha and 2.85 t /ha respectively. Overall results show that Mungbean-Wheat cropping system is not only economically better but is also soil health and environment friendly. It can also be helpful in the promotion of climate smart agriculture in this region.

Keywords: Mungbean; Wheat; cropping systems; Gran yields; Potohar Pakistan

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INTRODUCTION

Crop rotation plays a fundamental role in balancing inter-crop nutritional management, reducing biotic and a biotic stresses, inhibiting soil degradation and adapting to climate change (Reeves et al., 2016 and Gmach et al., 2020). Likewise rotation of nitrogen (N) - fixing and non – N- fixing crop is a recommended planting pattern to improve soil fertility in farmland (Lal., 2004 and Madari et al., 2005). Pulses need less nitrogen as external input because their maximum N requirement is met through the biological N-fixation (Kumar et al., 2014; Basu et al., 2016). Mungbean (*Vigna radiata* L.*)* is one of the most important pulse crops, and is being grown from the tropical to sub-tropical areas around the world. It is one of the most short duration legumes and needs 75 - 90 days to mature, so it has a great scope to be fit in any cropping system. Its water requirement is less and the cultivation of this crop is also relatively cheap as compared with the other crops. It is easily palatable, rich in iron (6 mg $[100g]^{-1}$ and protein (20-24%) of dry seed. It is easy in digestion, free from flatulence and in addition to nourishing people; it has a great value as an economical food and as a fodder crop. It sustains system productivity, maintains soil fertility by the addition of nitrogen through Rhizobial symbiosis and adds 33-37 kg of nitrogen (N) to the soil after harvest and thus helps in saving of about 25 percent of nitrogen for the succeeding crop (Sekhon et al., 2007). It has also been reported that planting of Mungbean crop in high rainfall areas of Potohar, can help farmers in sustaining system productivity through moisture conservation, by stabling economic benefits, improving soil nutrition and organic matter (Aslam, 1995).

Pakistan has 17 different agro-ecological zones and in 11 of these, rainfed agriculture prevails. Total cropped area of Pakistan is about 20.9 mha, of which 4.8 mha is rainfed and this rainfed area is mainly concentrated in the Potohar region, northern mountains and northern plains (Anonymous,1986). Potohar plateau is in the north eastern part of the Punjab province (Latitude $32^0 10'$ to $34^0 0'$) and longitude (71^0 10′ to 71^0 55′ E), having total area of 1.82 mha and its topography ranges from flat to gently undulating, locally broken by gullies and hill ranges. It comprises of Islamabad capital territory, and different districts mainly including Rawalpindi, Attock, Jehlum, and Chakwal and similarly some parts of districts Mianwali and Gujrat. The elevation of this region is 350 to 575 m (1150 to 1900 ft) and it is divided into three distinct rainfall zones i.e. high rainfall (>750 mm of annual rainfall), medium (500 to 750 mm) and low rainfall (<500 mm). In this region the maximum rainfall (about 80%) is received during summer i.e. June – September and 20% during the months of October to May. Soils of this region are alkaline, calcareous, low in organic matter and deficient in plant nutrients like N and P (Khan and Joergensen, 2006 and Nizami et al., 2004). This region mainly depends on rains and is characterized by a diverse and complex agriculture (Supple, 1985). Soils of this region are subjected to sheet and gully erosion and it is intensified with the commencement of monsoon rains due to the fallow system, where the absence of vegetation makes soil susceptible to erosion. This results in loss of soil organic

matter, plant nutrients and also reduce rate of water infiltration and soil water storage capacity. According to Ahmad et al., (1990), the annual loss of soil was 17-41 tones / ha due to fallow compared to 9-26 tones / ha, when the land was under crop. They also reported that there was 10-18% less run off due to cover crop, which reduced soil loss by 50%. They also mentioned that cropping intensity in this region is low and increasing it will improve resource productivity.

Potohar region is basically rainfed and there is a great potential for reducing fallow land with leguminous crops (Supple et al, 1985 and Byerlee et al.,1992) and Majid et al., (1990) reported that in medium rainfall areas, the farmers who have replaced fallow land with the Mungbean were capable to raise their net system income.

Wheat is the staple crop of Pakistan which is cultivated on an area of about 9.043 million hectares with the total production of about 27.634 million tones, while the area under Mungbean crop is planted 0.218 million ha with the production of 0.135 million tones (Economic Survey of Pakistan, 2022-23). Bhattacharyya et al., (2009) and Shah et al., (2003) reported enhanced soil organic matter and as well as more N-fixation by legumes, when they studied Mungbean-wheat and lentil-maize cropping systems. The adoption of Mungbean – Wheat system, instead of Fallow-Wheat system appears feasible in medium and high rainfall areas a mean of economically maintaining nitrogen balance in the agro-ecosystem and will provide opportunity for higher grain production and protein contents respectively.

The present adaptation trials of Mungbean – Wheat crop rotations were conducted on the farmer's fields to promote the adoption of Mungbean crop in the high and medium rainfall areas of the Potohar as compared with the Fallow-Wheat cropping system.

MATERIALS AND METHODS

During both kharif and rabi seasons of 2014-15 and 2016-17, adaptation plots of Mungbean-Wheat in comparison with Fallow – Wheat cropping system were planted on 5 different sites. Details of sowing and harvesting of both Mungbean and wheat crops are given in Tables 1, 2, 3 and 4.

During both years on all these sites, Mungbean variety NM-11 was planted by using the recommended farming practices. On all these sites, some area of each experimental plot was left fallow, for the further study for the establishment of wheat crop during the both rabi seasons i.e. 2014-15 and 2016-17. On all these sites only DAP fertilizer was applied to Mungbean crop @ 25 kg/acre. On all these sites Mungbean crop was planted by using the seed rate of 12 kg/acre. Appropriate herbicides were applied on Mungbean crop to control the different kinds of weeds. Data was recorded regarding crop germination, grain yield and different yield components. During both years on all these sites, wheat variety Pakistan-2013 was planted by using the recommended package of production for wheat crop, however during rabi season (2016-17) on one site i.e. village Behlot, Tehsil Fatehjang District Attock in case of Fallow-Wheat cropping system, farmer used his own seed.

Soil samples were collected from all these sites before the planting of both crops and were analyzed for the different parameters by using the standard procedures. Rainfall data of the Rawalpindi area was collected from the Met office Islamabad. Data for crops germination, grain yields and different yields components was recorded by collecting the three random samples from each site by using the 1 m^2 quadrate. Similarly data was recorded regarding changes in soil moisture contents of the top 100 cm soil depths at the time of sowing and harvesting of Mung bean crops and as well as before the sowing of wheat crops. Both years data was analyzed separately by using the Randomized Complete Block Design (RCBD) with three replications.

Estimated gross incomes of the both cropping systems have been calculated and for this purpose prices of Mungbean and wheat crop grains have been fixed Rs.150/kg and Rs.100/kg respectively.

Table 1. Sowing and harvesting of Mungbean crop planted on different famer's fields during the kharif season 2014.

S.No	Sites	Date of sowing	Date of harvesting
1.	Village Dhoke Lass, Tehsil Kallar Sydian District Rawalpindi	15-7-2014	1-10-2014
2.	Village Gullyana, Tehsil Gujjar Khan, District Rawalpindi	14-7-2014	30-9-2014
3.	Village Mohra Baba Fatih, Tehsil Gujjar Khan, District Rawalpindi	12-7-2014	1-10-2014
4.	Village Kurri, District Islamabad	18-7-2014	9-10-2014
5.	Village Kamil Pur Shairjang, Tehsil Jand, District Attock	11-7-2014	2-10-2014

Table 2. Sowing and harvesting of wheat crop on farmers fields during the rabi season 2014-15.

S.No	Sites	Date of sowing	Date of harvesting
1.	Village Dhoke Lass, Tehsil Kallar Sydian, District Rawalpindi	1-11-2014	24-5-2015
2.	Village Gullyana, Tehsil Gujjar Khan, District Rawalpindi	2-11-2014	29-4-2015
3.	Village Mohra Baba Fatih, Tehsil Gujjar Khan, District Rawalpindi	2-11-2014	25-4-2015
4.	Village Kurri, District Islamabad	5-11-2014	5-5-2015
5.	Village kamil Pur Shairjang, Tehsil Jand, District Attock	31-10-2014	6-5-2015

Table 3. Sowing and harvesting of Mungbean crop planted on different farmer's fields during the kharif season 2016.

S.No	Sites	Date of sowing	Date of harvesting
1.	Village Doultala, Tehsil Gujjar Khan, District Rawalpindi	25-7-2016	7-10-2016
2.	Village Mohra Baba Fatih, Tehsil Gujjar Khan, District Rawalpindi	29-7-2016	8-10-2016
3.	Village Sakruta, Tehsil Gujjar Khan District Rawalpindi	26-7-2016	7-10-2016
4.	Village Bania, Tehsil Taxila, District Rawalpindi	30-7-2016	6-10-2016
5.	Village Behlot, Tehsil Fatehjang District Attock.	23-7-2016	6-10-2016

Table 4. Sowing and harvesting of wheat crop on farmers fields during on farmer's fields during the rabi season 2016-17.

S.No	Sites	Date of sowing	Date of harvesting
1.	Village Doultala, tehsil Gujjar Khan, District Rawalpindi	7-11-2016	1-5-2017
2.	Village Mohra Baba Fatih, tehsil Gujjar Khan, District Rawalpindi	8-11-2016	21-4-2017
3.	Village Sakruta, Tehsil Gujjar Khan, District Rawalpindi	6-11-2016	22-4-2017
4.	Village Bania, Tehsil Taxila, District Rawalpindi	12-11-2016	30-4-2017
5.	Village Behlot, Tehsil Fatehjang, District Attock.	13-11-2016	30-4-2017

RESULTS AND DISCUSSION

Rainfall data of both kharif and rabi seasons (From the months of July to May) of the years 2010-11 to 2016-17 of Rawalpindi area is given in fig.1, which shows that in this area more rains are received during kharif season as compared to the months of October, November and December, however there are variations in the timings and quantities of rainfalls which are received during the months from January to May.

During kharif season 2014, yields of Mungbean crop planted on different sites varied from 0.57 t/ha to 0.72 t/ha, with the average yield of 0.62 t/ha. Similarly grain yields of Mungbean crop of kharif season 2016 also varied and maximum grain yield (1.53 t/ha) was recorded in case of crop which was planted in village Behlot followed by 1.15 t/ha in village Bania while minimum grain yield 0.62 t/ha was recorded in village Mohra Baba Fateh. Overall average grain yield of Mung bean crop of all these sites was 0.95 t/ha. Zahid et al., (1991) has also previously reported Mungbean grain yield i.e. 678 kg ha^{-1} planted in the Tehsil Fatehjang area, District Attock.

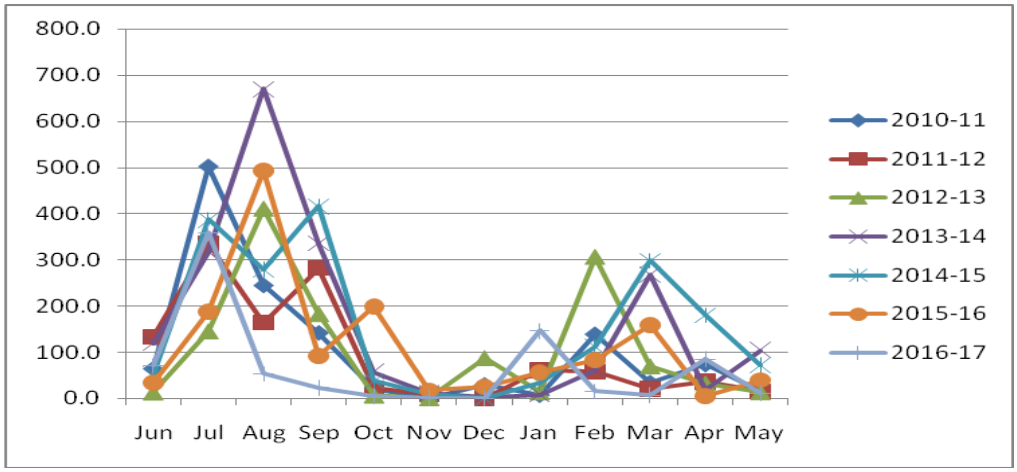

Figure 1. Variations in the rainfalls (mm) during the both kharif and rabi seasons of Rawalpindi region during the different years.

Due to heavy rains during kharif season, on some sights more vegetative growth of Mungbean crop was recorded, but it had a negative effect on grain yields of Mungbean crop of these sites.

In case of wheat crop better or at par wheat crop germination was recorded in case of Mung bean-Wheat cropping system as compared with the Fallow-Wheat cropping system (Tables 5 and 6). Similarly, overall better wheat crop tillering was recorded in case of Mungbean – Wheat cropping system as compared with the Fallow - Wheat cropping system. It might be due to residual soil moisture, which controls the crop germination and emergence through the imbibitions process, so it might be the reason due to which better wheat crop seedling stand establishment in Mungbean - Wheat cropping system was recorded as compared with the Fallow-Wheat cropping system. Soil moisture is an important element in rainfed ecosystem for obtaining satisfactory crop establishment. More soil moisture in the Mungbean-Wheat cropping system as compared with the Fallow-Wheat cropping system has been reported by Asim et al., 2006. Other reason might be the nitrogen fixed by the Mungbean crop, which mainly helps in the establishment of wheat crop. Higher grain yield in Mungbean-Wheat cropping system as compared with the Fallow-Wheat cropping system, is one of the important platitudes of this system over Fallow-Wheat cropping system. Similar findings have also been previously reported by Asim et al., (2006).

During rabi season 2014-15, although variations in wheat crop grain yields were recorded on all these sites under the different cropping systems but maximum wheat crop grain yield (4.44 t/ha) was recorded in case of Fallow-Wheat cropping system in village Gullyana, while minimum wheat crop grain yield (1.89 t/ha) was recorded in case of village Kamil Pur Fateh Shairjang. On two sites i.e. village Dhoke Lass and village Gullyana statistically at par grain yields were recorded in case of both i.e.

Mungbean-Wheat and Fallow-Wheat cropping systems, while on other three sites i.e. village Mohra Baba Fateh, village Kurri and village Kamil Pur Shairjang more wheat crop grain yields were recorded in case of Mungbean - Wheat cropping system as compared with the Fallow-Wheat cropping system. On over all basis during, rabi season 2014-15, maximum wheat crop grain yield (3.80 t/ha) was recorded in case of Mungbean - Wheat cropping system as compared with the Fallow-Wheat cropping system having grain yield of 3.15 t/ha respectively (Tables 5 and 6).

Table 5. Wheat crop grain yields and different yield components of the adaptation plots planted on different sites under the different cropping systems i.e. Mungbean-Wheat (M-W) and Fallow-Wheat (F-W) during the cropping season 2014-15.

Sites name	Ger./m^2		P.H (cm)		S. length(cm)		No of S. lets/spike		No of tillers/m^2		B.Y (t/ha)		G.Y (t/ha)	
	(M-W)	(F-W)	(M-W)	(F-W)	(M-W)	(F-W)	(M-W)	(F-W)	(M-W)	(F-W)	(M-W)	(F-W)	(M-W)	(F-W)
Village Dhoke Lass,	150.5a	150.3ab	98.4bcd	96.3de	11.1ab	11.9a	19.7ab	19.2abc	271.7b	336a	14.17bc	19.25a	4.29a	4.30a
Village Gullyana	136.0ab	134.7b	101.6bcd	92.0e	11.1ab	9.6d	18.5bc	16.8de	263.7b	256.7bc	15.60bc	12.85c	4.21ab	4.44a
Village Mohra Baba Fateh	146.3ab	148.7ab	107.9a	133.3ab	11.2ab	10.9abc	20.3a	19.0abc	250.0bc	206.7d	9.87 d	8.26de	3.52abc	2.82c
Village Kurri	148.3ab	149.0ab	101.9bc	97.0cde	10.0bcd	10.2bcd	18.1cd	18.1bcd	259.7b	226.2cd	13.58bc	9.56d	4.15ab	3.29c
Village Kamil Pur Shairjang	150.7a	135.2ab	93.0e	80.4f	11.8a	9.7cd	20.3a	16.3e	141.3e	127.7e	6.43ef	4.23f	2.83c	1.89d

Different letters within column/group indicate significant differences among treatments means at P<0.05 (LSD).

Table 6. Mean wheat crop grain yields and different yield components of the adaptation plots planted on different sites under the different cropping systems during the cropping season 2014-15.

Cropping System	Ger./m^2	P.H (cm)	Spike length(cm)	No of spike lets/spike	No of tillers/m^2	B.Y (t/ha)	G.Y (t/ha)
Mung bean-Wheat	146.4a	100.6a	11.1a	19.4a	237.3a	11.93a	3.80a
Fallow-Wheat	143.7a	93.8b	10.5b	17.9b	230.6a	10.83b	3.15b

Different letters within column indicate significant differences among treatments means at P<0.05 (LSD).

During rabi season (2016-17), variations in wheat crop grain yields were also recorded on all the sites and on two sites i.e. village Doultala and village Bania more grain yields were recorded in case of Mung bean-Wheat cropping system, while on three sites i.e. village Mohra Baba Fateh and village Sakrutta and village Behlot more wheat crop grain yields were recorded in case of Mungbean - Wheat cropping system

as compared with the Fallow - Wheat cropping system and on overall basis of all these sites although statistically at par grain yields were recorded in case of both cropping system, but Mungbean - Wheat cropping system gave 12.3% and 6% more biological yield and grain yield respectively as compared with the Fallow-Wheat cropping system (Tables 7 and 8).

Table 7. Wheat crop grain yields and different yield components of adaptation plots planted on different sites under the different cropping systems i.e. Mungbean-Wheat (M-W) and Fallow-Wheat (F-W) during the cropping season 2016-17.

Sites name	P.H (cm)		Spike length (cm)		No of spikelets/spike		No of tillers/m^2		B.Y (t/ha)		G.Y(t/ha)	
	M-W	F-W	M-W	F-W	M-W	F-W	M-W	F-W	M-W	F-W	M-W	F-W
Village Doultala	78.4c	97.6b	10.6a	11.1a	17.7bcd	17.0de	210.3bc	297.3a	6.31cd	9.29bc	2.61bcd	3.53abc
Village Mohra Baba Fateh	109.3a	102.7ab	11.6a	10.6a	18.6abcd	19.7abc	277.7ab	208.0 bc	11.59ab	6.99cd	3.39abc	2.55cde
Village Sakrutta	105.7ab	101.8ab	10.3a	10.1a	18.3abcd	17.9bcd	226.7abc	209.3bc	15.2a	13.5a	4.20a	3.88ab
Village Bania	96.0 b	99.4ab	10.5a	10.9 a	20.1ab	20.5a	217.7bc	172.0c	6.48cd	8.44bcd	2.40cde	3.01abcd
Village Behlot	81.2c	70.5c	10.2a	10.1a	16.5de	15.2e	228.3abc	266.0ab	6.67cd	5.37d	2.01de	1.30e

Different letters within column indicate significant differences among treatments means at P<0.05 (LSD).

Table 8. Mean wheat crop grain yields and different yield components of the adaptation plots planted on different sites under the different cropping systems during the cropping season 2016-17.

Cropping System	P.H (cm)	Spike length (cm)	No. of spikelets /spike	N o of tillers/m^2	B.Y (t/ha)	G.Y(t/ha)
Mung bean-Wheat	94.1a	10.6a	18.2a	232.1a	9.25a	2.92a
Fallow-Wheat	94.4a	10.6a	18.1a	230.5a	8.72a	2.85a

Different letters within column indicate significant differences among treatments means at P<0.05 (LSD).

The variations in overall productions of Mungbean crop and wheat crop on different sites and as well as during both years were mainly due to the variations of soil's nature, their fertility and similarly in the rainfalls timings and as well as their quantities etc (Fig. 1).

Foremost reasons for overall more wheat crop grain yields in the Mungbean-Wheat cropping system as compared with the Fallow – Wheat cropping system might be due

to the increase of soil fertility, reduction in the evaporation of water due to the coverage of the soil by the crop and suppression of weeds as compared with the Fallow-Wheat cropping system (Tables 6 and 8). More grain yields in the Mungbean – Wheat cropping system as compared with the Fallow-Wheat cropping system has also been previously reported by Aslam., (1995) and according to him, higher grain yield in Mungbean – Wheat cropping system as compared with Fallow-Wheat cropping system can be through moisture conservation and similarly through improvement of soil nutrition and organic matter by the Mungbean crop.

Agro-economic performance of both crops i.e. Mungbean and wheat varied during the both years (2014-15 and 2016-17) and on overall basis Mungbean - Wheat cropping system gave more gross income as compared with the Fallow-Wheat cropping system (Tables 9 and 10). The gross income from the Mungbean crop of different seasons was estimated from the average production of different sites. However, Mungbean higher yield can be achieved, as in one site (village Behlot), grain yield was 1.53 t/ha during crop season 2016-17. To get the maximum yield of Mungbean crop yield along with the adoption of best crop management practices, there is also need of developing and promoting of promising high yielding, disease resistant and climate resilient varieties. Theses varieties should be less sensitive to drought and as well as to heavy rains and should have also synchrony in maturity of pods and have less vegetative growth after the start of reproductive phase, have higher seed yield in the first flush and similarly should have tolerance to flower/pod shedding effects.

Table 9. Overall **e**stimated gross income (Rs) under the different cropping systems during cropping seasons 2014-15.

Cropping System	Expenditure during kharif season (Rs/ha)	Income during kharif season from Mungbean crop (Rs/ha)	Income during rabi season from wheat grain yields (Rs/ha)	Income of the system (Rs).
Mungbean-Wheat	60500	93000	380000	412,500
Fallow-Wheat	45000	-	315000	270000

Table 10. Overall estimated gross income (Rs) under the different cropping systems during cropping seasons 2016-17.

Cropping System	Expenditure during kharif season (Rs/ha)	Income during kharif season from Mungbean crop (Rs/ha)	Income during rabi season from wheat grain yields (Rs/ha)	Income of the system (Rs).
Mungbean-Wheat	60500	142500	292000	374,000
Fallow-Wheat	45000	-	282000	237000

Grain quality analysis of three different sites also showed better protein contents in the grains of wheat crop planted in Mungbean - Wheat cropping system as compared with the protein contents of wheat crop grains which was planted in the Fallow-Wheat cropping system (Fig. 2). Previous studies have also already shown the beneficial influences of crop rotation (Ciontu, C et al., (2010) at different levels including crop yields, as well as soil's physical and chemical properties (Alvaro-Fuentes, J. L. et al., 2008 and Chang, N.J. et al., 2020).

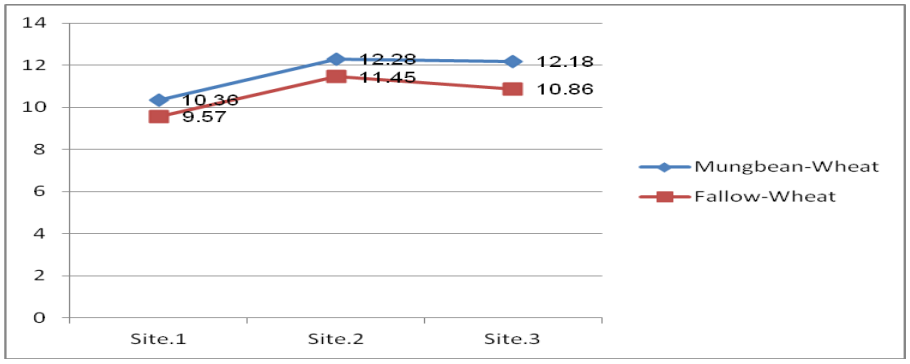

Figure 2. Wheat crop grains protein contents (%) of three different sites planted in Mungbean-Wheat (M-W) and Fallow-Wheat (F-W) cropping systems during rabi season 2014-15.

Results of our study are in line with the findings of Asim et al. (2006). According to them, Mungbean based cropping system in the high rainfall areas of Potohar will be supportive in sustaining the system productivity through moisture conservation, which is an important element in rainfed ecosystem for obtaining satisfactory crop establishment and similarly by enrichment of soil nutrition and as well as soil organic matter with the passage of time. More organic matter in the Mungbean – Wheat as compared with the Fallow-Wheat cropping system has been recorded (Figures 3, 4 and 5).

Figure 3. Average soil organic matter (%) of different sites under the different cropping systems i.e. Mungbean-Wheat (M-W) and Fallow-Wheat (F-W) at the sowing of wheat crop during rabi season 2014-15.

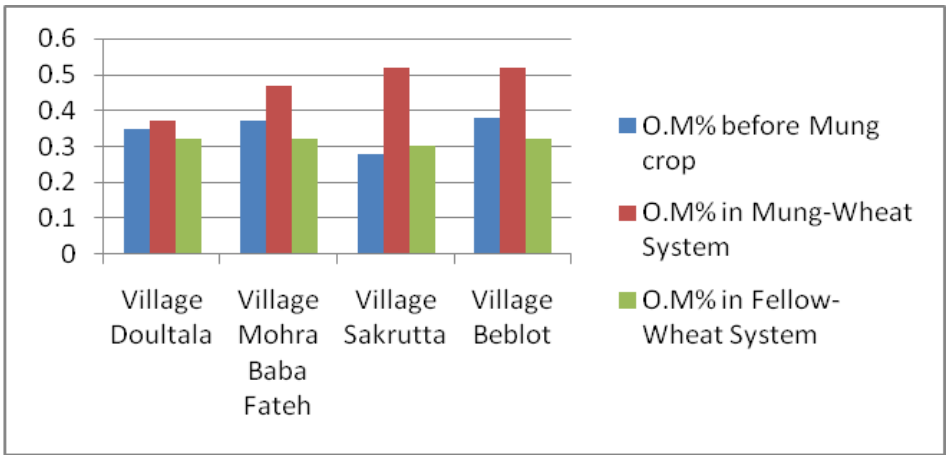

Figure 4. Soil organic matter (%) of different sites before the planting of Mungbean crop and as well as under the different cropping systems i.e. Mungbean-Wheat (M-W) and Fallow-Wheat (F-W) of different sites at the time of sowing of wheat crop during rabi season 2016-17.

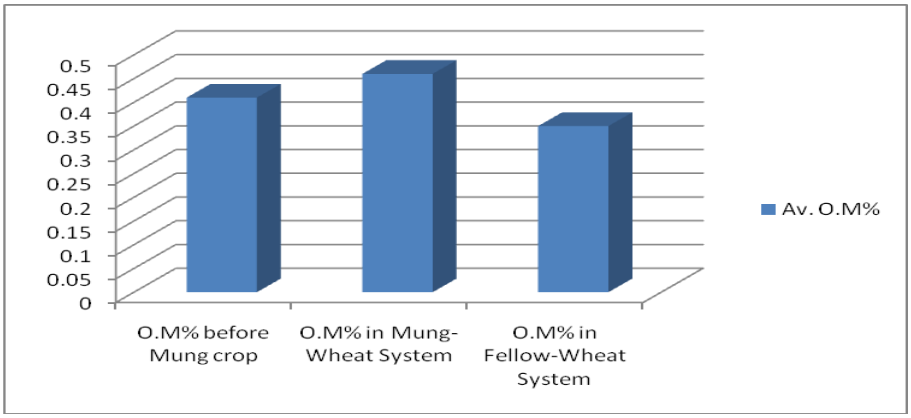

Figure 5. Average soil organic matter (%) of different sites before the planting of Mungbean crop and as well as under the different cropping systems i.e. Mungbean-Wheat (M-W) and Fallow-Wheat (F-W) at the time of sowing of wheat crop during the rabi season 2016-17.

More organic matter in the Mungbean - Wheat cropping system as compared to the Fallow – Wheat cropping system has also been previously reported by Asim et al., (2006) and according to them, nitrogen (NO_3^{-1}) and organic matter contents in the soil gradually increase with the passage of time, basically due to the high nitrogen concentration of tissues of Mungbean plants of the subsequent crop due to the fixation of free atmospheric nitrogen. Mungbean grown in rotation with wheat can

hold the soil N that might otherwise be lost by nitrification or leaching due to heavy rainfall during the kharif season. This indicates that Mungbean crop can contribute substantially to food production by enriching soil through biological nitrogen fixation and improving its physical condition, its quality and ultimately sustainability.

CONCLUSION

Study shows that in medium and high rainfall zones of this region, over all more wheat crop grain yields were recorded in the Mungbean –Wheat cropping system as compared with the Fallow-wheat cropping system. Through this farmers can get an additional income from the Mungbean crop. In addition by nutrient cycling in the total system; Mungbean crop can also reduce the need of nitrogen fertilizer by fixing it from the atmosphere and similarly it can enhance soil organic matter through its residues. It can reduce cost of production and by this cropping system, farmers will not keep land fallow and will not require ploughing up the land for a number of times, which will be supportive in the reductions of emissions of CO_2 from the soil into the atmosphere, ultimately it will have a positive effect on soil fertility. This cropping system can improve socio-economic condition of the farmers.

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