Research Article

Dynamics of Nutrients and Cation Exchange Capacity (CEC) under Different Crop Sequences and Tillage Systems in Subtropical Dry Land

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Abstract | Correct choice of crops and appropriate tillage systems are economically valuable for former depends on sufficient nutrient supply and satisfactory soil and climatic conditions. Moldboard plough (MP) (control), tine Cultivator (TC) and minimum tillage (MT) as main treatment, Crops sequence as subplot included were fallow–wheat (*Triticum aestivum*), (FW, control), mungbean (*Vigna radiata*)–wheat (MW), sorghum (*Sorghum bicolor*)–wheat (SW), green manure–wheat (GW) and mungbean-chickpea (MC) (*Cicer arietinum*). In summer in 2010-11 the highest nitrogen (N) concentration was under MT with GW (5.5 mg kg^{-1}), 2011-12 it was more in GW (6.13 mg kg^{-1}) under MP. In winter from second year it was highest in MP with MC (8.4 mg kg^{-1}). Phosphorus (P) and potassium (K) concentration second year it was highest under MT with MW (7.1 mg kg^{-1}) and with MC (72 mg kg^{-1}), respectively. The highest CEC at the end of winter from 2010-11 under MT in GW (3.67). Second year, in winter the highest CEC was under MT in SW (3.65 $cmol_c$ kg^{-1}). Micro nutrients iron (Fe) concentration from 2011-12 in winter was more under MT with GW (34.28 mg kg^{-1}). Copper (Cu) concentration in second year was highest under MT and MP with SW and GW (0.34 mg kg^{-1}). Zinc (Zn) concentration was highest in summer 2011-12 with MC (1.8 mg kg^{-1}). Ultimately, study documented the adaptation of MT with GW and legumes bases cropping system could batter option to improve fertility status in soil of Pothwar Pakistan.

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Introduction

Right selection of crop and tillage system is associated with nutrient availability which acts as foundation to attain maximum productivity under sustainable basis. Tillage and crop sequence consider as soil quality indicators (Zubair et al., 2017). The process of decomposition in leguminous crops more quick as compare to cereal due to low C:N ratio but the production quantity of cereal crop residue more that relapse to the soil have higher decomposition for cereals than for legumes crops (Xiao et al., 2010). Nutrient availability or release and cation exchange capacity (CEC) are deepened on soil permanent and variable charges which are also affected by conservation tillage with addition of legume crops in sequences (Marchuk et al., 2013).

Cropping sequences influence on soil macro and micro nutrient circulation in pools of different bioavailability and increased attention due to the importance of nutrients forms in combination with to environmental and agro ecological concerns. In soil nitrogen bio availability, fixation and circulation are largely dependent on C:N ratios of crop residues incorporated into soil and on the bioavailability of applied nitrogen as source fertilizer. However, long term loss of nitrogen due to it fixation and retention of fertilizers may improved by integration of crop to enhance N use efficiency in soil and plants (Verzeaux et al., 2017). Therefore, cereal crops like wheat, maize and oat can boost the efficiency of inoculation of mycorrhizal fungi and phosphates activity of in soil rizospher, thus endorse the organic phosphorus release into soil solution (Borie et al., 2002). Different filed practices like tillage and crop sequence increase the degree of contact between fertilizer derived nitrogen phosphorus, potassium and soil particles, there by prop up the formation of stable insoluble nitrogen phosphorus and potassium compounds (Phiri et al., 2001). Gradually, implementation of soil and crops best management practices (BMP) accelerate the organic matter buildup would be expected to improve macro and micro nutrition of crop is also connected with changes in morphology of plant root systems effected by tillage systems (Dias et al., 2015). Objective of designed experiment was management practices produce progressive qualitative and quantitative variations in soil nutrient bioavailability and cation exchange capacity of soil in subtropical dry land. Different form of nitrogen and phosphorus physical and chemical bases characterized those reflected in the total microbial biomass and enzymatic activities and, consequently, in the bio availability rates and nitrogen availability with depth (Bai et al., 2012).

Materials and Methods

Location and experimental layout

Two year field experiment was accomplished at the Research Farm of PMAS-Arid Agriculture University Rawalpindi, Pakistan (33° 38′ N, 73° 05′ E) from 2010 to 2012. The experimental area was part of a northern Punjab known as Pothwar plateau. Frequency of rain fall in the area is of bi-model, one in late summer (August and September) and second during the winter-spring (February and March) (Figure 1). Moonsoon rains are highly torrential and result in immense soil erosion. The mean temperature raises up 0.8 and 0.9 °C decade^{-1} for spring and fall, respectively (Tariq et al., 2004). The experimental soil was a clay loam having pH 7.79, ECe 0.25 dSm^{-1}, bulk density 1.4 Mg m^{-3}, N 3.35 mg kg^{-1}, P 6.50 mg kg^{-1} and K 130 mg kg^{-1}. The soil was classified as Rawalpindi Soil Series (Typic Ustocrepts; GOP, 1974) (Table 1).

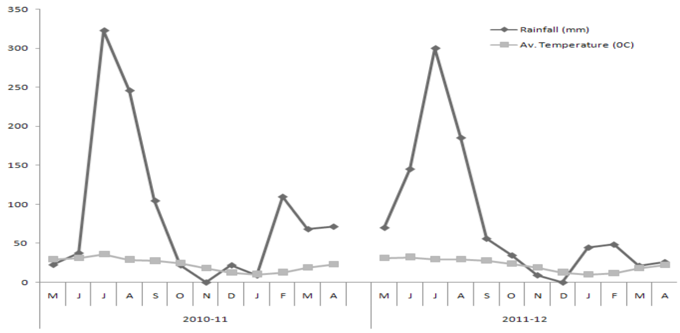

Figure 1: *Monthly rainfall (mm) and mean monthly temperature (°C) during the experimental period.*

Main plots had Moldboard Plough (MP, control), Conventional Tillage (CT) and Minimum Tillage (MT). Five sub plots with fallowing crop sequences *viz.* Fallow–Wheat (FW, control), Mungbean–Wheat (MW), Sorghum–Wheat (SW), Mungbean–Chickpea (MC) and Green manure–Wheat (GW) chopped residues sorghum and mungbean were added to soil. The main and sub plot sizes were 19m ×16 m and 2.5 ×16 m, respectively. MP treatment implicated moldboard ploughing at 25 cm depth. The MT consisted of maintaining the soil free of any tillage except for the seedbed preparation. Recommended dose of fertilizer 120-80-60 kg ha^{-1} was applied before the sowing of wheat. In minimum tillage plots, both summer and winter crop residues were returned back. Summer season crops *i.e.* mungbean (*Vigna radiata*) and sorghum (*Sorghum bicolor*) were planted in early July and harvest in September. Green manuring was carried out with a mixture of sorghum and mungbean. Winter season crops *i.e.* wheat (*Triticum aestivum*) and chickpea (*Cicer arietinum*) were planted in early November and harvested in April next year. Weeds in fallow plots were controlled by tine cultivator in MP plots while with herbicide glyphosate [N-(phosphonomethyl) glycine] in MT plots.

Measurements and calculations

For total nitrogen soil samples of 0.2 g weight were digested for two hours at 360^{0}C using 4.4 ml of digestion mixture included lithium sulphate, selenium, and hydrogen per oxide (H_2O_2). Then 50 ml of water was added and made up to 100 ml and mixed. Absorbance of sample were detected by using spectrophotometer at 665 nm wavelength (Anderson and Ingram, 1993).

Table 1: *Soil nitrate nitrogen as influenced by tillage systems and crop sequences.*

Nitrate-N												
	2010-11						2011-12					
	Winter sowing ^{NS}			Summer sowing			Winter sowing			Summer sowing ^{NS}		
	(mg kg^{-1})											
	Tine Culti-vator	Mould-board Plow	Min. Tillage	Tine Culti-vator	Mould-board Plow	Min. Tillage	Tine Culti-vator	Mould-board Plow	Min. Tillage	Tine Culti-vator	Mould-board Plow	Min. Tillage
Fallow-Wheat	6.7	4.4	5.2	5.2ab	1.6d	2.9bcd	6.4 cd	8.6 a	6.4 cd	6.7	4.5	5.3
Mungbean- Wheat	4.6	5.0	5.1	4.1bc	3.4bcd	3.5bcd	6.6 c	5.7 e	6.7 c	4.7	5.1	5.1
Sorghum- Wheat	1.7	5.1	3.0	3.4bcd	2.2cd	4.4ab	6.7 c	6.5 c	5.9 de	1.7	5.2	3.1
Green manure- Wheat	4.57	6.1	5.5	5.0ab	3.4bcd	5.5a	6.7 c	6.4 cd	7.9 b	4.6	6.1	5.6
Mungbean-Chickpea	4.8	3.7	4.9	5.2ab	4.7ab	3.9abc	5.0 f	8.4 a	5.0 f	4.8	3.8	4.9

Means sharing a common letter in the respective category are not significantly different at 1% or 5% probability.

Table 2: *Soil available phosphorus as influenced by tillage systems and crop sequences.*

Available phosphorus												
	2010-11						2011-12					
	Winter sowing ^{NS}			Summer sowing			Winter sowing			Summer sowing ^{NS}		
	(mg kg^{-1})											
	Tine Culti-vator	Mould-board Plow	Min-imum Tillage	Tine Culti-vator	Mould-board Plow	Min-imum Tillage	Tine Culti-vator	Mould-board Plow	Min-imum Tillage	Tine Culti-vator	Mould-board Plow	Min-imum Tillage
Fallow-Wheat	5.6	2.9	5.1	6.2abc	5.3cde	5.1cde	3.1	3.0	2.7	4.6def	5.1cde	3.4ef
Mungbean- Wheat	4.4	7.5	3.8	4.8cdef	4.7cdef	6.9ab	3.0	3.8	2.6	3.6def	3.7def	7.1a
Sorghum- Wheat	6.0	5.4	4.5	6.5abc	4.4def	6.2abc	2.8	3.0	2.7	5.6abc	5.3abc	4.1cdef
Green manure- Wheat	5.1	5.3	7.0	7.0a	5.3bcd	3.2f	2.8	2.7	3.7	3.1f	3.4ef	5.9abc
Mungbean-Chickpea	5.2	5.5	4.0	3.8ef	5.5bc	4.8cdef	3.0	2.9	3.6	6.6ab	3.3ef	4.5cdef

Means sharing a common letter in the respective category are not significantly different at 1% or 5% probability.

Available Phosphorus five gram of soil was taken into 250 ml flask with 100 ml of 0.5M of sodium bicarbonate ($NaHCO_3$). 50 ml volumetric flask 10 ml of filtrate was added into along with 1 ml of 5N sulphuric acid (H_2SO_4). In order to build attain the color, 8 ml of reagent ascorbic acid will be added. Total volume was being made up to 50 and transmittance will be recorded 10 minutes after color development using Spectrophotometer (Kuo, 1996). For determination of potassium, 5 g soil was taken into 50 ml centrifuge tube, and 33 ml 1N ammonium acetate solution added with 57 ml acetic acid to 700 ml DI water, followed by addition of 68 ml ammonium hydroxide and was shaken for 5 minutes on a shaker. After that extract will be collected in volumetric flask by passing through a filter paper. The process will be repeated three times and each time extract will be collected. Solution was diluted to 100 ml with ammonium acetate ($C_2H_7NO_2$) and concentration of potassium in soil extract will be determined on flame photometer (Ryan and Garabet, 1994). Micronutrients cations soil was taken into 125 ml Erlenmeyer flask; 20 ml extraction solution (DTPA) was added. Micronutrients will be directly measured by using atomic absorption spectrophotometer (ASS) (Lindsay and Norvel, 1978). Cation Exchange Capacity (CEC) about 4g soil will be taken in centrifuge tube 33 ml of 1N sodium acetate solution was added. Centrifuged at 3000 rpm and supernatant will be discarded four times. Then centrifugation will be carried out with 33ml ethanol. Sodium contents in the supernatant will be measured by flame photometer (Ryan and Garabet, 1994).

Statistical analyses

The main plot effect (tillage × year interaction) was tested with appropriate error term for the split plot design. Cropping sequence and other effects were tested by using the residual error. The year effect was tested using a "Combine Experiment" Model 1 (SAS 9.2),

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Table 3: *Soil extractable potassium as influenced by tillage systems and crop sequences.*

Extractable potassium												
	2010-11						2011-12					
	Winter sowing ^{NS}			Summer sowing			Winter sowing			Summer sowing ^{NS}		
	(mg kg^{-1})											
	Tine Culti-vator	Mould-board Plow	Min-imum Tillage	Tine Culti-vator	Mould-board Plow	Min-imum Tillage	Tine Culti-vator	Mould-board Plow	Min-imum Tillage	Tine Culti-vator	Mould-board Plow	Min-imum Tillage
Fallow-Wheat	45	40	35	166	70	197	60 b	24bcd	55cd	68 ab	41.6 c	26 cd
Mungbean- Wheat	85	55	85	98	89	177	30cd	34abcd	37abc	64 b	67 ab	69 ab
Sorghum- Wheat	85	75	40	84	114	87	63a	50cd	25 d	66 b	55 bc	56 bc
Green manure- Wheat	45	40	60	80	118	239	39ab	55cd	65 ab	58 bc	66 b	63.5 b
Mungbean-Chickpea	40	40	40	208	177	98	31cd	37bc	64 ab	56 bc	41bc	72 a

Means sharing a common letter in the respective category are not significantly different at 1% or 5% probability.

Table 4: *Soil iron (Fe) as influenced by tillage systems and crop sequences.*

Iron												
	2010-11						2011-12					
	Winter sowing ^{NS}			Summer sowing			Winter sowing			Summer sowing ^{NS}		
	(mg kg^{-1})											
	Tine Culti-vator	Mould-board Plow	Min-imum Tillage	Tine Culti-vator	Mould-board Plow	Min-imum Tillage	Tine Cultiva-tor	Mould-board Plow	Min-imum Tillage	Tine Culti-vator	Mould-board Plow	Min-imum Tillage
Fallow-Wheat	5.1abc	2.9c	5.2abc	2.0d	10.0.b	7.6bc	12.1cde	4.7f	30.7ab	9.39	6.5	13.0
Mungbean- Wheat	4.4abc	7.5a	3.9bc	7.1bc	8.1b	7.0bc	22.1bc	12.7cde	17.2cde	11.3	5.3	6.5
Sorghum- Wheat	6.1abc	5.4abc	4.5abc	4.0cd	8.2b	7.5bc	21.2bc	8.6def	5.6ef	13.2	11.0	5.8
Green manure- Wheat	5.2abc	5.4abc	7.1ab	15.6bc	6.8bc	7.6bc	20.3bcd	4.4f	34.8a	12.7	9.7	3.7
Mungbean-Chickpea	5.2abc	6.2abc	4.1abc	6.7b	15.4 a	7.5bc	13.5cdef	5.4ef	17.3cde	11.2	11.7	3.1

Means sharing a common letter in the respective category are not significantly different at 1% or 5% probability.

with the block within year effect as the error term. The LSD values were computed at the probability level of $\geq$ 0.05.

Results and Discussion

Nitrogen, phosphorus and potassium

In winter season at the start of experiment and summer at the end of experiment nitrogen (N) content had no differences (Table 1). However, in summer season in 2011 the highest nitrogen concentration was under MT with GW (mg kg^{-1}) and least was under MP with FW (1.6 mg kg^{-1}). In the second year in winter season from 2011-12 it was highest in MP with MC (8.4 mg kg^{-1}) followed by GW (5.2 mg kg^{-1}) under MT. However, in summer season it was more was in GW (6.13 mg kg^{-1}) under MP and under TC in FW (6.37 mg kg^{-1}). Phosphorus (P) concentration (Table 2) at the winter season of both year was not considerable. However, it was highest in TC (7.0 mg kg^{-1}) with GW and least was again in GW under MT (3.22 mg kg^{-1}). However, in the in second year from 2011-12 it was highest under MT with MW (7.1 mg kg^{-1}) and also under TC with (MC 6.6 mg kg^{-1}). In winter season it had the least concentration in GW (7.13 mg kg^{-1}) under TC tillage system.

Potassium (K) concentration (Table 3) in second year result were statistically significant. Second year from 2011-12 it was highest in MC and GW under MT (65 and 64 mg kg^{-1}) and also under TC with SW (65 mg kg^{-1}). Least was under MT with SW (25 mg kg^{-1}). in summer season highest concentration was in MT with MC (75 mg kg^{-1}) followed by SW while least quantity of concentration was under MP with FW and MC cropping sequence (41 mg kg^{-1}).

Table 5: *Soil cupper (Cu) Nutrients as influenced by tillage systems and crop sequences.*

Iron												
	2010-11						2011-12					
	Winter sowing ^{NS}			Summer sowing			Winter sowing			Summer sowing ^{NS}		
	(mg kg^{-1})											
	Tine Culti-vator	Mould-board Plow	Min-imum Tillage	Tine Culti-vator	Mould-board Plow	Min-imum Tillage	Tine Culti-vator	Mould-board Plow	Min-imum Tillage	Tine Culti-vator	Mould-board Plow	Min-imum Tillage
Fallow-Wheat	0.2abc	0.2abc	0.1abc	0.2abc	0.2abc	0.1abc	0.1bcd	0.2abc	0.2abcd	0..1d	0.2cd	0.2cd
Mungbean- Wheat	0.2abc	0.2abc	0.3ab	0.3abc	0.2abc	0.3ab	0.1cd	0.2abcd	0.2abcd	0.2c	0.2cd	0.2cd
Sorghum- Wheat	0.2abc	0.2abc	0.2 abc	0.2abc	0.2abc	0.2abc	0.3ab	0.2abc	0.3a	0.3ab	0.2bc	0.3abc
Green manure- Wheat	0.3a	0.3a	0.2 abc	0.3a	0.3a	0.2abc	0.2abc	0.3a	0.1d	0.3ab	0.2cd	0.4a
Mungbean-Chickpea	0.1c	0.1 bc	0.2 abc	0.1c	0.1bc	0.2abc	0.2abc	0.1bcd	0.2abc	0.2cd	0.23cd	0.2cd

Means sharing a common letter in the respective category are not significantly different at 1% or 5% probability.

Table 6: *Soil Micro (Zn) Nutrients as influenced by tillage systems and cropping sequences.*

Iron												
	2010-11						2011-12					
	Winter sowing ^{NS}			Summer sowing			Winter sowing			Summer sowing ^{NS}		
	(mg kg^{-1})											
	Tine Cultiva-tor	Mould-board Plow	Min-imum Tillage	Tine Culti-vator	Mould-board Plow	Min-imum Tillage	Tine Culti-vator	Mould-board Plow	Min-imum Tillage	Tine Cultiva-tor	Mould-board Plow	Min-imum Tillage
Fallow-Wheat	5.08abc	2.91c	5.18abc	1.28bc	0.44c	0.57bc	0.98c	0.33c	1.04c	0.66ef	0.98 de	0.97cdef
Mungbean- Wheat	4.41abc	7.52abc	3.88bc	1.49bc	0.73bc	1.05bc	1.2 a	1.025c	1.17c	1.08cde	0.87def	1.16cde
Sorghum- Wheat	6.03abc	5.41abc	4.49abc	0.56bc	0.94bc	1.55 b	0.92c	0.72c	1.48c	1.40bcd	1.09cde	1.19cde
Green manure- Wheat	5.14abc	5.36abc	7.03ab	2.71a	1.40bc	1.02 bc	4.86b	0.85c	1.05c	1.29bcd	1.43bc	0.92cdef
Mungbean-Chickpea	5.20abc	6.22abc	4.06abc	1.21bc	0.95bc	1.16 bc	0.9c	0.60c	0.57c	0.505f	1.05cde	1.78ab

Means sharing a common letter in the respective category are not significantly different at 1% or 5% probability.

Iron, copper and zinc

In micro nutrients iron (Fe) concentration was statistically significant in all cropping season except in summer at the end of 2012. The highest concentration in winter season at the start of experiment was under MP with MW cropping sequence (7.5 mg Kg^{-1}) than fallowed by GW under MT (7.05 mg kg^{-1}). Least was under MP with FW (2.9 mg kg^{-1}). In summer season it was the highest in MC (15.31 mg kg^{-1}) under MP least was under TC with FW (2.03 mg kg^{-1}). In second year in winter season it was more under MT with GW (34.28 mg kg^{-1}) least was in FW under MP (4.72 mg Kg^{-1}) (Table 4).

Copper (Cu) at the start of experiment was highest under TC and MP with GW (0.33 mg kg^{-1}) and (0.32 mg kg^{-1}) followed by MW (0.30 mg Kg^{-1}) in MT same trend was in summer season. From 2011-12 it was highest under MT and MP with SW and GW (0.34 mg kg^{-1}) and least was under MT with GW (0.04 mg kg^{-1}). In summer season it was highest under MT with SW (0.41 mg kg^{-1}) least was under TC with FW (0.13 mg kg^{-1}) (Table 5).

Zinc (Zn) concentration at the start of experiment was highest in GW under MT (7.03 mg kg^{-1}) and least was in MP under FW cropping sequence (2.91 mg kg^{-1}). In summer it was more in TC with GW (2.71 mg kg^{-1}) than followed by SW (1.55 mg kg^{-1}) under MT. From 2011-12 it was the highest under TC with MW (1.2 mg Kg^{-1}) then followed by TC with GW (4.8 mg Kg^{-1}) and least was under all MT treatments. In summer season it was the highest under MT with MC (1.78 mg kg^{-1}) least was under TC with MC (0.505 mg kg^{-1}) (Table 6).

Cation Excnahge Capacity (CEC)

The results showed that at the end of first winter season year from 2010-11 the highest CEC was under the MP in SW (3.11 cmol$_c$ kg^{-1}) and GW (3.12 cmol$_c$ kg^{-1})

Table 7: *Cation Exchange Capacity (CEC) as influenced by tillage systems and crop sequences.*

Sampling seasons	Tillage systems / Rotations	Fellow-Wheat	Mung-bean-Wheat	Sor-ghum-Wheat	Greenma-nur-Wheat	Mung-bean-Chickpea	Mean
		cmole charge kg^{-1}					
Winter 2010-11	MP	2.94 b	2.71 c	3.11 a	3.12 a	2.69 cd	2.40
	MT	3.00 ab	2.43 e	2.55 de	2.97 ab	2.93 b	2.91
	TC	1.90 f	1.75g	3.02ab	2.91b	2.44e	2.78
Summer 2010-11	MP	3.64 bc	3.45 d	3.91 a	3.92 a	3.43 cd	2.64
	MT	3.70 b	3.14 e	3.25 e	3.67 b	3.62 bc	3.65
	TC	0.26 f	2.45 g	3.72 b	3.61 bc	3.14 e	3.48
Winter 2011-12	MP	3.37 abcd	3.19 bcd	3.21 abcd	3.31 abcd	3.54 abc	3.19
	MT	3.31 abcd	3.11 cde	3.65 a	3.04 de	2.733 de	3.32
	TC	3.21 abcd	3.06 de	2.69 de	3.59 ab	3.38 abcd	3.17
Summer 2011-12	MP	4.05 b	4.89 b	4.84 b	3.84 b	4.25 b	4.99
	MT	7.55 a	5.19 ab	3.90 b	3.78 b	7.35 a	5.72
	TC	4.59 b	4.79 b	5.11 b	5.25 b	3.98 b	4.66

Means sharing a common letter in the respective category are not significantly different at 1% or 5% probability.

cropping sequences than followed by MT in FW (3.00 $cmol_c\ kg^{-1}$). In winter season from 2010-11 the highest CEC again was in SW and GW (3.91 and 3.92 $cmol_c\ kg^{-1}$), respectively. Under MT the highest CEC was in GW (3.67) and least was under TC in (MW 2.45 $cmol_c\ kg^{-1}$) as in first year (1.75 $cmol_c\ kg^{-1}$).

In the second year from 2011-12, in winter season the highest CEC was observed under MT in SW (3.65 $cmol_c\ kg^{-1}$) remaining plots CEC was not noticeable under different tillage and cropping sequences. However, in summer season the highest CEC was under MT in GW and FW (7.35 and 7.55 $cmol_c\ kg^{-1}$) than followed by MW (5.19 $cmol_c\ kg^{-1}$) (Table 7).

Minimum tillage with adoptable crop rotation could increase the nutrients availability for dry land agriculture especially in semiarid zones. It was observed that the No till had higher P, K and Cu ac compared to MT and higher most of micro and macro nutrients in the upper layers due to the higher organic matted and fact that these systems maintain surface applied K and P and K fertilizer. On the other hand, neither SOC nor N was affected by crop rotation (Martin et al., 2007). The reason of more nutrient concentration under MT because nutrients release from crop residues depends on microbial immobilization/ mineralization of N (and C) as influenced by crop residue added though conservation tillage practices.

Wheat is a major cereal crops with a protein content, which is consumed by human being and is grown all around the world in diverse agro ecological zones. Pakistan is 6th among wheat producing countries with production of about 24 million tons, wheat is a staple food (Iqbal and Jinap, 2013). Punjab province is the largest producer of wheat in Pakistan, accounting for 76 percent of the area under wheat cultivation and 80 percent of the wheat produced in the country (Quddus and Mustafa, 2012). Chickpea is the most widely grown pulse in Pakistan, occupying an area of 1.05 million hectare and production of 0.57 million tons (GoP, 2010). Production can be enhanced on sustainable basis if BMPs are adopted to enhance carbon use efficiency.

Soil organic carbon as source of nutrient could be improved by crop rotations with best tillage and other management practices (Martin et al., 2007). The reason of more nutrient concentration under MT because nutrients release from crop residues depends on microbial immobilization/ mineralization of N (and C) as influenced by crop residue added though conservation tillage practices.

The highest CEC was observed under MT because returns of the residues enhance microbial activity which also improves the CEC of soil. Reversing degradation and desertification through enhancement and preservation of Soil organic carbon (SOC) would enhance CEC (Shrestha and Lal, 2011). Decline in soil quality can positively relate the CEC (Russell et al., 2006). It was observed by Liu et al. (2014) CEC of surface soil (0–17 cm) was 45.8 meq/100 g for uncultivated soil, 42.6 meq/100 g for the soil of 5-year cultivation, 38.1 meq/100 g for 14-year cultivation, and 31.5 meq/100 g for 50-cultivation. Reduction of CEC with the increase in cultivation time was because of depletion of organic matter with passage of time. Results are also in accord with the findings of that under MT system SOC was enhanced, but without significant results. MT could more significant by the enhancement of the CEC under barely and wheat cropping sequences (Ben et al., 2007).

Conclusions and Recommendations

Outcome of study reveal that legume bases cropping system especially creels (maize and wheat) grown along (mungbean and chickpea) under minimum tillage practices are potentially more suitable for small and large scale framers to sustain fertility status of soil under subtropical dry land of Photwar, Punjab Pakistan.

Author's Contribution

Asma Hassan conceived idea and conducted protocal Zuhair Hasnain participated in overall management of article Shahzada Sohail Ijaz conducted data analyses Muhmmad Rasheed helped out to improve manuscript Muhmmad Ansar prepared first draft Lubna Ayub Durani improved the language, Ajaz Ahmad provided technical input and Muhmmad Bilal Ali wrote literature review.

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