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EFFECT OF DRYING-REWETTING DURATIONS IN COMBINATION WITH SYNTHETIC FERTILIZERS AND CROP RESIDUES ON SOIL FERTILITY AND MAIZE PRODUCTION

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Abstract

Alternate wetting and drying boost decomposition of organic matter and various nutrient transformation processes to change the nutrient availability for plant uptake. Integrated nutrient management is important to reduce the use of synthetic fertilizers, sustain soil fertility and maize production. Repeated pots and two-year field experiments were conducted to estimate the effects of synthetic fertilizers and crop residues under different DRW (drying rewetting cycles). All fertilizer treatments caused remarkable increase in soil organic carbon (SOC), available nitrogen (AN), available phosphorus (AP), extractable potassium (K), maize chlorophyll content, maize dry biomass and grain yield, especially under 14 days of alternate wet dry cycles. Mung bean straw caused more increase in SOC, AN, AP, while½ NPK + ½ mung bean straw caused more increase in maize chlorophyll content and dry biomass. Maximum increase in soil K was observed with recommended NPK in both experiments. Significant effects regarding C/N ratio and soil pH were noted with the solo application of mung bean straw and rice straw. Maximum increase in grain yield (20%) was achieved with ½ NPK + ½ mung bean straw. In conclusion, integration use of crop straw and inorganic fertilizers with alternate wetting and drying may help harvest better maize yield on sustainable basis.

Key words: Combined use of organic and inorganic fertilizer sources, Crop residue, Alternate wetting and drying cycles, Soil health, Maize crop.

Introduction

In the coming decades, considerable global changes in rainfall and evapotranspiration will result drying/wetting series in most of regions (Borken & Matzner, 2009). Large area of the world is predicted to face the drought (Field, 2012). Regions with high amount of annual precipitation, high evapotranspiration or shift in rainfall pattern increasing the prospect of severe water scarcity worldwide which will cause irregular and extreme drought stress for plants and soil organisms (Borken & Matzner, 2009). In xeric (arid) and the regions which receives precipitation below the potential evapotranspiration (semi-arid regions), the temporal distribution of rainfall are highly uneven, and hence water availability is a vital factor in driving soil processes (Sun *et al.,* 2017). Under repeated wetting and drying soil undergoes a complex physi-biochemical changes. For example, Soil surface is commonly practicing ongoing drying and rewetting cycles, as a result of high evapotranspiration and low rainfall or irrigation (Göransson *et al.,* 2013; Wang *et al.,* 2014). These DRW (drying rewetting cycles) cycles affects nutrient and water uptake by plant and the microbial activity involved in the mineralization and immobilization process, leading to diverse soil nutrient bioavailability (Dodd, 2009; Du *et al.,* 2015). In general, a positive effect of alternate soil drying and rewetting on nutrient release like N and P mineralization was observed (Venterink, 2002). Some microbes have the ability to survive with low water potential (soil drying) due to accumulation of osmoregulatory solutes in their bodies (Yao *et al.,* 2011). Rewetting of dry soil causes bursting of cells and leads to microbial death while other microbes release the accumulated solute and survives (Shi & Marschner, 2014; Hu *et al.*, 2015a, 2015b). To meet the food demand of growing population the area under irrigated agriculture is increasing in order to secure crop production (Wang *et al.*, 2017).

Maize (*Zea mays* L.) is a vital grain crop and ranked as third important cereal after wheat and rice in Pakistan. It was cultivated on an area of 1.13 million hectares during 2015-16. Average maize yield in Pakistan is 4,155 kg ha^{-1} and total annual maize production is 4.69 million tones (GOP, 2015). The definite and possible yield gap of maize should be minimized to manage with food security crisis due to recklessly increase in world population. For the time being, global nitrogen and phosphorus fertilizers consumption has been increased dramatically which are expected to rise further in coming decades (Wang *et al.,* 2017). There is a wide gap in total fertilizer use and nutrient consumption ratio was monitored. Only 30-50% of applied N and about 45% of applied P is taken up by plants and the rest of those nutrients are lost in the environment causing contamination of both surface and ground water quality due to runoff and leaching (Wang *et al.,* 2017).

Low organic matter status is one of the other major constraints in low crop productivity. Semi-arid regions of Pakistan are low in organic matter (<1%) and the use of mineral fertilizers is also ineffective because there is not enough moisture for diffusion or mass flow (Malik *et al.*, 2013). Now a days various legume crops and straws of exhaustive crops are preferred to incorporate in the soil for the maintenance of fertility status. So, the availability of soil nutrients (N, P and K) can be increased through incorporating the crop residues in to the soil (Zhang *et al.*, 2002). The use of crop residues as organic amendment is effective strategy to enhance nutrient availability and FUE (fertilizer use efficiency) (Mousavi *et al.*, 2012; Rehmut *et al.*, 2012; Lungmana, 2013). The combined use of inorganic fertilizers with crop residues may help to increase residues decomposition for quick release of nutrients and less phytotoxic and possible growth enhancement effect on crop at lower doses of phytotoxins (hormesis) (Abbas *et al.*, 2017). According to Macharia (2002), nutrients availability and uptake by plants can be improved with combined use of crop straw amendment and moisture contents.

To use of synthetic fertilizers is more common as it is economical, easy to apply and fast response than other organic sources. However, the intensive application is causing land degradation, destroying soil micro flora and nutrient leaching to underground water damaging environment, human and livestock health. There is an exigent need to develop strategies to integrate organic fertilizer sources with synthetic fertilizers in step with principles of viable development. Accordingly, the aim of present study was to determine the efficiency of integrated application of crop residues and synthetic fertilizers under alternate wetting and drying conditions on soil fertility and maize production.

Material and Method

Experiment I: combined effect of synthetic fertilizers and crop straw under drying-rewetting cycles on soil nutrient availability and maize growth

To assess the influence of drying-rewetting cycles and different fertilizer treatments on soil fertility and growth of maize crop, a pot study was conducted at Soil Physics Laboratory, UAF (University of Agriculture Faisalabad). The temperature setting was 20 to 25 ± 2ºC and 14-h photoperiod and relative humidity ranged from 28-55%. The experimental units (pots) were settled in a CRD (completely randomized design) with four repetitions. Soil was air-dried, ground and sieved (2mm sieve) to analyse soil physico-chemical properties. Soil physico-chemical properties are given in table 1. All the pots were filled with experimental soil (sandy clay loam soil). Crop straws with high and low C/N ratio mentioned as amendments were dried, ground and passed through sieve of 2mm size. All the organic (crop straw) and inorganic (amendments were mixed uniformly. Crop straws (organic amendments were applied @ 1g/Kg (1% on weight basis). For microbial activation soil was pre-incubated at 60% WHC (water holding capacity) for 10 days. Soil moisture content were maintained by weighing and adding the water at what time needed. In 1st phase four moisture treatments with 28 days length was provided. In wetting and drying treatments, the number of wetting and drying period was different and refereed as 28M (60% WHC for 28days), 14M (no water addition from 0-14 days, 60% WHC form 14-28 days) and 28D (no water addition for 28 days). Six types of amendments including T_o (Control), T_1 (recommended NPK), T_2 (½ NPK of recommended + mung bean), T_3 (½ NPK of recommended + rice straw), T_4 (mung bean) and T_5 (rice straw) were mixed in soil erstwhile the moisture treatment.

Table 1. Physico-chemical properties of experimental soil.

Characteristics	Values
Sand	59%
Silt	16%
Clay	25%
Soil textural class	Sandy clay loam
Bulk density	1.47Mg m^{-3}
Saturated hydraulic conductivity	2.46X 10^{-4} cm s^{-1}
Organic matter	0.79%
EC_e	2.39dS m^{-1}
pH	8.1
Total nitrogen	0.05%
Available phosphorus	9.02mg kg^{-1}
Extractable potassium	131mg kg^{-1}

In 2nd phase at day 28 all pots were brought to 60% WHC. Maize seeds were presoaked and the seedlings were transplanted to the pots. K_2CrO_7–H_2SO_4 oxidation procedure was followed to measure soil organic carbon. Ratio of organic Carbon to Nitrogen was used to calculate soil C/N ratio. Soil inorganic n content were determined as the sum of NO3-N and NH4-N in the extract of 2M KCl (MAFF 1986). Olsen method was followed to determine available phosphorus (Olsen *et al.*, 1954). Soil available K (Potassium) contents were measured by using flame photometer (Richards 1954). Before few days of harvesting the maize crop, the chlorophyll contents were measured through SPAD. Repeated experiments gave statistically non-significant results therefore, assembled data was statistically analysed.

Experiment II: Combined effect of synthetic fertilizers and crop straw under drying-rewetting cycles on soil nutrient availability and maize production under field conditions

Site description: Field trials were conducted for consective 2 years at Agronomic Research Area, UAF, Faisalabad, Pakistan (73˚06’E altitude, 31˚26’N latitude), during the year of 2014-15 and 2015-16. Vacated field after the harvesting of rice crop was selected and the physio-chemical characteristics of experimental soil are given in table 1. Faisalabad climate is semi-arid with 10-15ppm winter rain fall and relative humidity about 60%. During the both years of stud, metrological data were obtained from AgroMet. Observatory, Department of Crop Physiology, UAF (Table 2).

Table 2. Effects of different fertilizer plus organic amendments treatments on chlorophyll contents and dry biomass of maize 45 days after planting.

Treatments	Chlorophyll contents (SPAD)			Dry biomass (g/pots each pot 5 plants)		
	28M	14M	28D	28M	14M	28D
T0	32.1 ± 0.11h	36.3 ± 0.2fgh	34.3 ± 0.15h	1.885 ± 0.12b	1.865 ± 0.13b	1.86 ± 0.45b
T1	43.3 ± 0.23b-e	42.4 ± 0.16a-c	40.7 ± 0.20b-f	2.735 ± 0.5a	2.795 ± 0.35a	2.655 ± 0.23a
T2	42.3 ± 0.21b-f	43.6 ± 0.13a	39.3 ± 0.19b-f	2.685 ± 0.4a	2.835 ± 0.15a	2.625 ± 0.6
T3	41.2 ± 0.18c-h	39.8 ± 0.22b-d	39.7 ± 0.12b-g	2.635 ± 0.34a	2.835 ± 0.4a	2.585 ± 0.39a
T4	40.4 ± 0.13c-h	43.6 ± 0.17a	38.6 ± 0.16d-h	2.485 ± 0.13ab	2.935 ± 0.15 a	2.385 ± 0.19ab
T5	39.6 ± 0.19d-h	39.7 ± 0.21b-d	40.1 ± 0.18e-h	2.405 ± 0.32ab	2.885 ± 0.39 a	2.335 ± 0.48ab
				0.6340		

T_o: no fertilizer; T_1: recommended NPK; T_2: ½ NPK of recommended + Mung bean; T_3: ½ NPK of recommended + rice straw; T_4: mung bean straw and T_5: Rice straw. The means within the same column with the same letter are not differed significantly at the 5% confidence level. The data are the means ± standard error

Experimental details: Maize hybrid 30R50 was sown on ridges during spring season. Suggested seed rate @ 20 kg/ ha was used keeping 75 cm row to row and 20 cm plant to plant distance on 03 August in 2015 and 06 August in 2016. Suggested fertilizers doses for field study were 250-120- 125 kg hec^{-1} of N, P and K respectively were applied in the experimental plots in the form of urea fertilizer containing 46% of N, diammonium phosphate fertilizer with 46% of P_2O_5 and 18% of N and sulfate of potash having 50% of K_2O. Various fertilizer treatments comprising T_o (control), T_1 (Recommended NPK), T_2 (½ NPK ha^{-1} + ½ mung bean residue), T_3 (½ NPK ha^{-1} + ½ rice straw), T_4 (mung bean straw) and T_5 (rice straw) were uniformly mixed in to soil before moisture treatment. 1/5th of nitrogenous fertilizer and whole of phosphatic and potassic fertilizers were broadcasted and merged into soil at the time of final seed bed preparation. However, left over N doses (one bag for each application) were applied at crop height of 1 foot, at 2 feet, at 3 feet and at the stage of tasseling (5-7 days before tasseling) by fertigation method. Straws of mung bean and rice were chopped in to small pieces of 3-5cm size for ease incorporation in the soil. Drying-rewetting cycles which showed the best results under pot studies (14M) for 28 days before moisture and wheat planting was applied in the relevant plots whenever the preferred soil moisture level depleted. Water holding capacity was maintained by measuring the depth of irrigation water described by Mujumdar (2002).

$$d = (Fc - M_b)(Bd) \times D/100$$

Here;

d = irrigation water depth (cm), D = root zone depth (cm), F_c = Field capacity in % by weigh, Bd = Soil bulk density (g/cm^3), M_b= moisture contents in soil before irrigation by weight. Water discharge applied to each experimental plot was determined with the aid of a cut throat flume (3' x 8"). The time required to supply the requisite depth of irrigation water to each plot was designed according to following equation (Rafiq, 2001):

$$t = \frac{1.02\, d \times a}{(q)}$$

Whereas,

t = time in hours, d = depth of water in inches, a = area in acres, q = irrigation water discharge in cubic feet per second (ft^3/s), 1.02= conversion factor (from acre to hectare and inches to cm). Herbicides were sprayed to kept the weeds under ETL (economic thresh hold level) in the field. At the full maturity the maize crop was harvested on 06th November, 2015 and 10th November, 2016.

Experimental design, observations and statistical analyses: A field experiemnt was conducted under RCBD (Randomized complete block design) with four replicas under factorial arrangments. Soil available N, P, K content, organic carbon and chlorophyll content of maize were measured following same procedures defined in pot studies. Grain yield of maize was determined from each experiemntal plot by harvesting them separately and converted to t ha^{-1}

All the data collected from each experiemntal unit of both pot and field studies were collected separately and the data subjected to Fisher's analysis of variance and Tukey's HSD test at 5% probability level was used to copare their means their means (Statistix 8.1, Analytical software, Statistix; Tallahassee, FL, USA, 1985-2003). The data of both years are described separately, as the statistical analysis showed significant year effect.

Results

Maize growth and leaf chlorophyll content under greenhouse: Maize growth and leaf chlorophyll contents were not improved during constant moisture content (Table 4). Alternate drying and rewetting (14M) caused more increase in chlorophyll contents whereas constant moisture content (28M) and 28 days dry (28D) provided minimum chlorophyll contents (Table 4). Interactive effect revealed that application of mung bean straw at 14M performed well regarding chlorophyll content as compared to all other treatment combination and followed by recommended NPK and ½ NPK+ ½ mung bean straw at same moisture treatment (Table 4). The interaction data showed that dry biomass of maize was increased significantly under crop residue during DRW (Table 4). All NPK plus organic amendment treatments produced drier biomass (1.86-2.95g) at 14M interval as compared to 28D and 28M. Maximum dry biomass was produced in pots those were treated with mung bean at 14M that was followed by ½ NPK+ ½ mung bean straw, ½ NPK+ ½ mung bean straw and rice straw alone at same moisture level (Table 4).

Table 3. Effects of different fertilizer plus organic amendments treatments on total organic carbon and soil available nitrogen, phosphorus and potassium.

Treatments	Total organic carbon (g kg^{-1})			N (mg kg^{-1})			P (mg kg^{-1})			K (mg kg^{-1})		
	28M	14M	28D	28M	14M	28D	28M	14M	28D	28M	14M	28D
T_0	8.45 ± 0.50ef	8.570±0.75d-f	7.570±1.0f	65±2.50e	72±2.75de	60±3.0e	12±1.75h	11±1.3h	09±1.25h	19.5±6.5f	22.5±6.0ef	20.5±5.2f
T_1	12.41 ± 1.80b-f	13.11±1.33b-e	11.23±0.77c-f	89±6.30be	99±4.75a-e	81±5.0de	16±4.89f-h	27±5.75c-e	14±3.15gh	47.5±6.23ab	50.5±5.75a	43.5±4.8a-c
T_2	11.83 ± 0.65c-f	13.83±0.90b-e	11.45±1.5c-f	87±6.0c-e	125±5.5a-c	86 ± 4.0c-e	22±5.0d-g	30±4.85b-d	24±4.0d-f	37.5±5.85b-d	42.5±5.0a-c	30.5±4.9d-f
T_3	13.07 ± 1.65b-f	14.07±1.35b-d	12.35±1.28b-f	76±2.80de	114±3.75a-d	90±4.25b-e	22±3.75d-g	35±4.15a-c	21±3.25e-g	35.5±4.75cd	37.5±4b-d	33.5±5.64c-e
T_4	17.34 ± 1.0ab	21.87±0.80a	15.43±1.75bc	81±3.35de	138±4.75a	108±5.25a-d	30±4.5b-d	42±3.85a	27±4.75c-e	28.5±4.25d-f	32.5±6.3c-e	26.5±5.78d-f
T_5	16.17 ± 1.38bc	17.67±1.48ab	14.67±1.62bc	74±4.15de	131±5.15ab	99±5.75a-e	24±5.25d-f	37±5.5ab	26±4.85de	26.5±4.0d-f	34.5±6.45cd	27.5±5.10d-f
CV	5.5060			42.155			8.6774				11.706	

T_o: no fertilizer; T_1: recommended NPK; T_2: ½ NPK of recommended + Mung bean; T_3: ½ NPK of recommended + rice straw; T_4: mung bean straw and T_5: Rice straw. The means within the same column with the same letter are not differed significantly at the 5% confidence level. The data are the means ± standard error

Soil organic carbon under greenhouse: The application of crop residue increased soil organic carbon content (Table 1) Combined effect of organic and inorganic fertilizer treatment along DRW cycles showed maximum increase (155%) in soil organic carbon content in pots studies after the sole application of mung bean straw along (Table 3) which was followed by rice straw application at the same moisture level. Lowest organic C content were observed in control that was followed by pots those were treated with sole application of NPK without organic amendments. Significant difference in organic carbon content was observed after the application of organic amendments during alternate drying and rewetting (14M) and constant moisture content (28M and 28D) (Table 3).

Available nitrogen, phosphorus and potassium content in soil under greenhouse experiment: Interactive effect of various fertilizer treatment and alternate wetting and drying cycle was significant regarding soil available N (nitrogen), P (phosphorus) and K (potassium) content. Drying and rewetting events showed maximum increase in nitrogen, phosphorus and potassium contents as compared to treatments applied with constant mosit (28M) and constant dry cycles (28D). There were 91 and 81% increase in available N content after mung bean straw and rice straw application alone respectively as compared to control (14M). Alike treatments showed maximum increase (231% and 236%) in soil available P content. Nevertheless, high concentration (22-50 mg kg^{-1}) of extractable soil k content was attained in pots treated with recommended dose of NPK (Table 3).

Soil organic carbon under field conditions: Application of crop residue increased soil organic carbon content as compared to inorganic fertilizer treatment (Table 5). Maximum soil organic carbon content (149 and 127%) was recorded in sole rice straw and mung bean straw treatment in 2015-15 and 2015-16 respectively.

Soil available nitrogen, phosphorus and potassium under field conditions: The results of soil samples (0-15cm) after wheat harvesting showed that application of crop residues alone and in combination with inorganic fertilizer has a significant interactive effect regarding soil available N (nitrogen), P (phosphorus) and K (potassium) contents in two year studies. Application of mung bean straw showed an increase in N (60-110, 68-134 mg/kg) and P (8-34, 9.8-39 mg/kg) contents in the year of 2014-15 and 2015-16 respectively. While high K (20-43, 23-45mg/kg) content were observed after the application of recommended NPK in both year of studies (Table 5).

C/N ratio and soil pH under field conditions: Interactive effect of organic and inorganic fertilizer treatments during drying and rewetting was significant regarding C/N ratio and pH. Low C/N was observed in mung bean straw treatment which was followed by ½ recommended NPK+ ½ mung bean straw and ½ recommended NPK+ ½ rice straw. Similarly, application of crop residue significantly influenced soil pH. Soil pH was significantly reduced with the application of mung bean and rice straw as compared to all other treatments which was followed by ½ recommended NPK+ ½ mung bean straw and ½ recommended NPK+ ½ rice straw in both year of studies (Fig. 1).

Leaf chlorophyll contents and maize grain yield: In the year of 2014-15 application of recommended NPK caused maximum chlorophyll content (19%). While, in the year of 2015-16 ½ recommended NPK and ½ mung bean straw showed 20% higher chlorophyll content as compared to control (Table 6). Similarly, the interactive effect of inorganic fertilizer and crop straw was significant regarding maize grain yield. Application of ½ recommended NPK and mung bean caused maximum increase in maize grain yield (20%) as compared to control). Furthermore, other fertilizer treatments including T_3, T_4 and T_5 caused 13-13%, 8.62-8.67% and 5.5-5.54% increase in grain yield, respectively (Table 6).

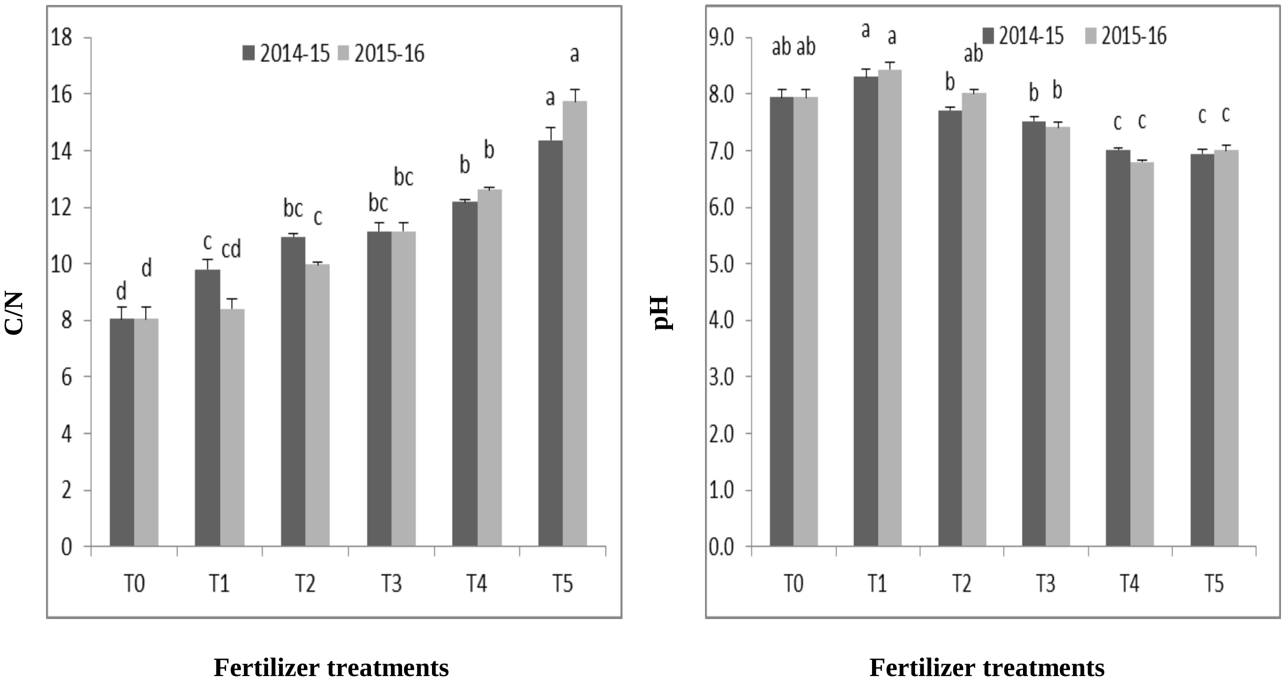

Fig. 1. Effect of various fertilizer treatments on C/N ratio and soil pH during 2014-15 and 2015-16. T_0: control, T_1: 200-15-100 Kg NPK ha^{-1}, T_2: 100-75-50 Kg NPK ha^{-1} + mung bean straw 4 t ha^{-1}, T_3: 100-75-50 Kg NPK ha^{-1} + rice straw 4 t ha^{-1}, T_4: mung bean straw 8 t ha^{-1} and T_5: Rice straw 8 t ha^{-1}. Bars indicate standard error of mean. Means with different letters are significantly different from each other at the 95% confidence level.

Table 4. Effects of different fertilizer plus organic amendments treatments on chlorophyll contents and dry biomass of maize 45 days after planting.

Treatments	Chlorophyll contents (SPAD)			Dry biomass (g/pots each pot 5 plants)		
	28M	14M	28D	28M	14M	28D
T0	32.1 ± 0.11h	36.3 ± 0.2fgh	34.3 ± 0.15h	1.885 ± 0.12b	1.865 ± 0.13b	1.86 ± 0.45b
T1	43.3 ± 0.23b-e	42.4 ± 0.16a-c	40.7 ± 0.20b-f	2.735 ± 0.5a	2.795 ± 0.35a	2.655 ± 0.23a
T2	42.3 ± 0.21b-f	43.6 ± 0.13a	39.3 ± 0.19b-f	2.685 ± 0.4a	2.835 ± 0.15a	2.625 ± 0.6
T3	41.2 ± 0.18c-h	39.8 ± 0.22b-d	39.7 ± 0.12b-g	2.635 ± 0.34a	2.835 ± 0.4a	2.585 ± 0.39a
T4	40.4 ± 0.13c-h	43.6 ± 0.17a	38.6 ± 0.16d-h	2.485 ± 0.13ab	2.935 ± 0.15 a	2.385 ± 0.19ab
T5	39.6 ± 0.19d-h	39.7 ± 0.21b-d	40.1 ± 0.18e-h	2.405 ± 0.32ab	2.885 ± 0.39 a	2.335 ± 0.48ab
				0.6340		

T_0: no fertilizer; T_1: recommended NPK; T_2: ½ NPK of recommended + Mung bean; T_3: ½ NPK of recommended + rice straw; T_4: mung bean straw and T_5: Rice straw. The means within the same column with the same letter are not differed significantly at the 5% confidence level. The data are the means ± standard error

Table 5. Effects of different fertilizer plus organic amendments treatments on total organic carbon and soil available nitrogen, phosphorus and potassium.

Treatments	Soil organic carbon (g kg^{-1})		N (mg kg^{-1})		P (mg kg^{-1})		K (mg kg^{-1})	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
T_0	9.070 ± 0.53a	8.64 ± 1.0f	60 ± 3.21e	68 ± 3.0d	8.00 ± 0.21d	9.80 ± 0.25d	20 ± 1.21d	23 ± 1.5d
T_1	11.21 ± 2.03d	10.92 ± 1.75e	92 ± 5.50cd	91 ± 5.25c	22 ± 3.11c	25.80 ± 3.0c	43 ± 3.76a	45 ± 3.5a
T_2	15.65 ± 0.75c	13.17 ± 1.d	104 ± 4.5ab	112 ± 4.0b	28 ± 2.5b	33.80 ± 2.75b	35 ± 3.15b	39 ± 1.8b
T_3	17.34 ± 1.90bc	15.93 ± 1.45c	99 ± 3.45bc	96 ± 3.5c	30 ± 1.75b	31.80 ± 1.5b	36 ± 3.25b	37 ± 3b
T_4	22.67 ± 1.65a	17.53 ± 1.85b	110 ± 3.75a	134 ± 3.25a	34 ± 2.25a	39.80 ± 1.9a	24 ± 2.75cd	30 ± 3.25c
T_5	19.54 ± 0.93b	19.64 ± 1.95a	90 ± 5.0d	120 ± 4.20b	29 ± 2.85b	32.80 ± 1.45b	27 ± 1.75c	29 ± 2.5c
cv	2.3144	1.4105	7.959	11.282	3.9330	5.0057	4.145	4.0567

T_0: no fertilizer; T_1: recommended NPK; T_2: ½ NPK of recommended + Mung bean; T_3: ½ NPK of recommended + rice straw; T_4: mung bean straw and T_5: Rice straw. The means within the same column with the same letter are not differed significantly at the 5% confidence level. The data are the means ± standard error

Table 6. Effects of different fertilizer plus organic amendments treatments on chlorophyll contents and grain yield of maize at maturity during 2014-15 and 2015-16.

Treatments	Chlorophyll contents (SPAD)		Maize grain yield (t ha^{-1})	
	2014-15	2015-16	2014-15	2015-16
T0	31.2 ± 0.11d	29.4.4 ± 0.21e	8.35 ± 0.32e	8.300 ± 0.35e
T1	49.5 ± 0.23a	48.1 ± 0.14b	9.83 ± 0.65a	9.780 ± 0.61a
T2	48.7 ± 0.18b	49.3 ± 0.20a	10.05 ± 0.60a	10.00 ± 0.55a
T3	47.6 ± 0.13b	46.3 ± 0.10c	9.45 ± 0.35b	9.400 ± 0.40b
T4	46.2 ± 0.19c	45.6 ± 0.22c	9.07 ± 0.49c	9.02 ± 0.f49c
T5	45.9 ± 0.17c	42.6 ± 0.15d	8.81 ± 0.55d	8.76 ± 0.6d

T_0: control, T_1: 200-15-100 Kg NPK ha^{-1},T_2: 100-75-50 Kg NPK ha^{-1} + mung bean straw 4 t ha^{-1}, T_3: 100-75-50 Kg NPK ha^{-1} + rice straw 4 t ha^{-1}, T_4: mung bean straw 8 t ha^{-1} and T_5: Rice straw 8 t ha^{-1} .The means within the same column with the same letter are not differed significantly at the 5% confidence level. The data are the means ± standard error

Discussion

Soil available P significantly varied in all wet/dry (14M) cycles particularly the treatments with mung bean straw and rice straw during 14M showed significant increases in P content. This increase might be due to the addition of crop straw which served both as a source of P and effective in P mobilization. It agrees with the studies of Nash *et al.*, (2005) and Ray (2006) that slowly release of P from organic sources is smaller but frequent which increase the nutrient availability for crop and reduce the fixation process (Hussain *et al.*, 2003). More release in P (phosphorus) was observed during alternate drying and rewetting as compared to soil with constant moisture content Turner *et al.*, (2001). Overall an increase in nutrient availability was observed after DRW which might be the reason of soil aggregate degradation because during soil drying there is an exposure of organic matter surfaces and rewetting of these soil surfaces again cause disruption by swelling (Ouyang & Li, 2013). Van Gestel *et al.*, (1993) indicated that up to 58% of the total microbial biomass may be killed by soil drying and rapid rewetting. Turner *et al.*, (2003) confirmed that bacterial cell lysis is the source of water-extractable organic P after soil drying. Increased N content after soil drying and rewetting were observed which were same as reported by Grootjans *et al.*, (1986). The DRW (14M) resulted higher N content as compared to soil with constant moisture content. However, nitrogen mineralization rate in our studies are fell in the range of rates measured in pots with constant moisture (60%WHC) (Venterink *et al.*, 2002). Although C/N ratio has long been known to be an important factor in monitoring the rate from which N is released from crop straw (Kumar & Goh, 1999; Lal, 2004; Johnson *et al.*, 2010). Straw with narrow C/N ratio and low lignin contents decomposed rapidly and made the nitrogen more available as compared to other straw (high C/N ratio) (Kamkar *et al.*, 2014). In field, high N contents were observed in rice straw along with 14M which is diverging the studies of (Kamkar *et al.*, 2014) that the use of straw with high C: N ratio is not advisable as it does not allow the straw to be performed as an effective internal field input. While high N contents were also observed in mung bean straw which is in accordance with the studies of Kamkar *et al.*, (2014) who reported the quick release of nutrients after leguminous crop straw incorporation. Findings proved that increase in total N content in mungbean straw treatments was not only be due to less C:N ratio of crop straw but also by wet and dry cycle.

Total organic carbon was higher in treatments with the application of crop straw which is consistent with the previous studies and can be explained by the findings of Kabirinejad (2014) that the addition of crop straw increases the soil organic matter content which ultimately buffers the soil pH.

Leaf chlorophyll contents are important indicator of crop health and growth to insure higher yield. In our research, chlorophyll contents were significantly increased with 14D moisture treatment along with different inorganic and organic fertilizer treatments. High chlorophyll contents are the reason of increase available nutrient content for maize. A strong correlation between available content and cholorophyl content of plant was reported by Bojovic & Markovic (2009). Furthermore, Amujoyegbe *et al*., (2007) stated more increase in chlorophyll contents in organic fertilizer treatments as compared to inorganic NPK applications, which concept is diverging to the present studies where inorganic fertilizer treatment also showed good results along 14D moisture treatment. Increase in nutrient contents after alternate wetting and drying is might be the reason of aggregate disruption. Exposure of new soils and organic matter surfaces after drying and further disruption of these surfaces by swelling after rewetting which increases the nutrient availability and ultimately plant uptake (Ouyang & Li, 2013).

There was high biomass production of maize in mung bean straw treated plot with 14D moisture treatment followed by combined application of organic and inorganic sources of fertilizers. Residual effect of legumes is responsible in maintaining the fertility status of soil (Toomsan, 2012). Increase in maize production might be the reason of high nutrients availability and uptake by crop. Turner *et al*., (2003) reported that lysis of bacterial cell results in increase nutrients in soil and an important source of plant available P content. Increase in nutrient contents in alternate wetting and drying treatments is might be the reason of degradation of aggregates in result of soil drying results in exposure of new soils and organic matter and rewetting of these soil surfaces are further disrupted by swelling which in result increases nutrient availability in soil and ultimately plant uptake (Ouyang & Li, 2013).

More maize grain produce was achieved after the application of ½ NPK plus mung bean straw, in previous study Ghosh *et al*., (2004) noticed a considerable increase in yield after the interactive application of NPK and organic fertilizers as compared to application of inorganic fertilizer alone. This is correlated with the Bunemann *et al*., (2013) studies who observed high maize yield after organic fertilizer application (Bunemann *et al*., 2013). Kamkar *et al*., (2014) observed high crop grain yield when there is addition of low C/N ratio straw as low C/N ratio straw can supply more N to plants during the grain filling period. Maximum grain yield of maize was owed to incorporation of inorganic fertilizer with crop straw (Mandal *et al*., 2004) and enhancing decomposition through alternate wet and dry events (Borken and Matzner, 2009). Low maize yield when high C/N ratio straw was added had recognized to a less contribution of N from this straw (Kamkar *et al*., 2014). Integrated use of crop straw and inorganic fertilizer will impact positively on soil health, environment and good economic return to farmers. Please write an attractive conclusion. Follow some good related articles.

References

Abbas, T., M.A. Nadeem,.A. Tanveer, S. Syed, A. Zohaib, N. Farooq and M.A. Shehzad. 2017. Allelopathic influence of aquatic weeds on agro-ecosystem: a review. *Planta Daninh*., 35: e017163146.

Amujoyegbe, B.J., J.T. Opabode and A. Olayinka. 2007. Effect of organic and inorganic fertilizer on yield and chlorophyll content of maize (*Zea mays* L.) and sorghum *Sorghum bicolour* (L.) Moench. *Afr. J. Biotechnol*., 6: 1869-1873.

Bojovic, B. and A. Markovic. 2009. Correlation between nitrogen and chlorophyll content in wheat (*Triticum aestivum* L.). *Kragujevac J. Sci*., 31: 69-74.

Borken, W. and E. Matzner. 2009. Reappraisal of drying and wetting effects on C and N mineralization and fluxes in soils. *Glob. Chang. Biol*., 15: 808-824.

Buneman, P., E.V. Kostylev and S. Vansummeren. 2013. March. Annotations are relative. In: Proceedings of the 16th International Conference on Database Theory. pp. 177-188. ACM

Dodd, I.C. 2009. Rhizosphere manipulations to maximize 'crop per drop'during deficit irrigation. *J. Exp. Bot*., 60: 2454-2459.

Du, T., S. Kang, J. Zhang and W.J. Davies. 2015. Deficit irrigation and sustainable water-resource strategies in agriculture for China's food security. *J. Exp. Bot*., 66: 2253-2269.

Field, C.B (Ed.) 2012. Managing the risks of extreme events and disasters to advance climate change adaptation: special report of the intergovernmental panel on climate change. Cambridge University Press.

Ghosh, P.K., P. Ramesh, K.K. Bandyopadhyay, A.K. Tripathi, K.M. Hati, A.K. Misra and C.L. Acharya. 2004. Comparative effectiveness of cattle manure, poultry manure, phosphocompost and fertilizer-NPK on three cropping systems in vertisols of semi-arid tropics. I. Crop yields and system performance. *Bioresour. Technol*., 95: 77-83.

Göransson, H.D.L., D. Godbold, L. Jones and J. Rousk. 2013. Bacterial growth and respiration responses upon rewetting dry forest soils: impact of drought-legacy. *Soil Biol. Biochem*., 57: 477-486.

Grootjans, A.P., P.C. Schipper and H.J. Van der Windt. 1986. Influence of drainage on N-mineralization and vegetation response in wet meadows: II Cirsio-Molinietum stands. *Acta Oecol*., 7: 3-14.

Hu, H.W, C.A. Macdonald, P. Trivedi, B. Holmes, L. Bodrossy, J.Z. He and B.K. Singh. 2015b. Water addition regulates the metabolic activity of ammonia oxidizers responding to environmental perturbations in dry subhumid ecosystems. *Environ. Microbial*., 17: 444-461.

Hu, H.W., D. Chen and J.Z. He. 2015a. Microbial regulation of terrestrial nitrous oxide formation: understanding the biological pathways for prediction of emission rates. *FEMS Microbiol. Rev*., 39: 29-749.

Johnson, J.M., D.L. Karlen and S.S. Andrews. 2010. Conservation considerations for sustainable bioenergy feedstock production: If, what, where, and how much? *J. Soil Water Conserv*. 65: 88A-91A.

Kabirinejad, S., M. Kalbasi, A.H. Khoshgoftarmanesh, M. Hoodaji and M. Afyuni. 2014. Effect of Incorporation of Crops Straw into Soil on Some Chemical Properties of Soil and Bioavailability of Copper in Soil. *Int. J. Adv. Biol. Biomed. Res*., 2: 2819-2824.

Kumar, K. and K.M. Goh.1999. Crop straws and management practices: effects on soil quality, soil nitrogen dynamics, crop yield, and nitrogen recovery. *Adv. Agron*., 68: 197-319.

Lal, R. 2004. Is crop straw a waste? *J. Soil Water Conserv*., 59: 136A-139A.

Lungmana, M.G. and P.K. Patra. 2013. Effect of integrated nutrient management on available phosphorus influencing grain and straw yield of rice (cv. IR-36) in an Alfisol. *J. Crop Weed*. 9: 89-93

Macharia, P.N. and W.N. Ekaya. 2002. Effect of Moisture Availability on Nitrogen and Phosphorus Uptake by Plants Under Semi-arid Soil Conditions. *J. Hum. Ecol*., 13: 357-361.

Malik, M.A., K.S. Khan and P. Marschner.2013. Microbial biomass, nutrient availability and nutrient uptake by wheat in two soils with organic amendments. *J. Soil Sci. Plant Nutr*., 13: 955-966.

Mandal, K.G., A.K. Misra, K.M. Hati, K.K. Bandyopadhyay, P.K. Ghosh and M. Mohanty. 2004. Rice straw-management options and effects on soil properties and crop productivity. *J. Food Agri. Environ.*, 2: 224-231.

Mousavi, S.F., M. Moazzeni, B. Mostafazadeh-Fard and M.R.Yazdani. 2012. Effects of rice straw incorporation on some physical characteristics of paddy soils. *J. Agric. Sci. Technol.*, 14: 1173-1183.

Mujumdar, D.K. 2002. Irrigation water management: princilpes and practices. 2nd ed. Prentice hall of India, New Delhi-11000. pp. 487.

Nash, D., L. Clemow, M. Hannah, K. Barlow and P. Gangiya. 2005. Modeling phosphorus exports from rainfed and irrigated pastures in southern Australia. *Aust. J. Soil Res.*, 43: 1-11.

Ouyang, Y. and X. Li. 2013. Recent research progress on soil microbial responses to drying–rewetting cycles. *Acta Ecol. Sin.*, 33: 1-6.

Rafiq, M. 2001. A textbook of irrigation and drainage practices for agriculture. University of Agriculture Faisalabad Pakistan, pp. 69-70.

Ray von Wandruszka, 1. 2006. Phosphorus retention in calcareous soils and the effect of organic matter on its mobility. *Geochem. Trans.*, 7: 6.

Rehmut, M., J. Schoenauand and L. Jefferson. 2012. Effect of forage legumes on phosphorus availability to the following wheat crop in a black chernozem.

Shi, A and P. Marschner. 2014. Drying and rewetting frequency influences cumulative respiration and its distribution over time in two soils with contrasting management. *Soil Biol Biochem*., 72: 172-179.

Sun, Y., F. Yan and F. Liu. 2013. Drying/rewetting cycles of the soil under alternate partial root-zone drying irrigation reduce carbon and nitrogen retention in the soil–plant systems of potato. *Agric. Water Manag*., 128: 85-91.

Turner, B.L. and P.M. Haygarth. .2001. Phosphorus solubilization in rewetted soils. *Nature,* 411: 258.

Turner, B.L., R. Baxter and B.A. Whitton. 2003. Nitrogen and phosphorus in soil solutions and drainage streams in Upper Teesdale, northern England: implications of organic compounds for biological nutrient limitation. *Sci. Total Environ*., 314: 153-170.

Van Gastel, M., R. Merckx and K. Vlassak. 1993a. Microbial biomass responses to soil drying and rewetting: the fate of fast- and slowgrowing microorganisms in soils from different climates. *Soil Biol. Biochem*., 25: 109-123.

Venterink, H.O., N.M. Pieterse, J.D.M. Belgers, M.J. Wassen and P.C. De Ruiter. 2002. N, P, and K budgets along nutrient availability and productivity gradients in wetlands. *Ecol. Appl*., 12: 1010-1026j.

Wang, Y., C.R. Jensen and F. Liu. 2017. Nutritional responses to soil drying and rewetting cycles under partial root-zone drying irrigation. *Agric. Water Manag*., 179: 254-259.

Wang, Y., Y. Hao, X.Y. Cui, H. Zhao, C. Xu, X. Zhou and Z. Xu. 2014. Responses of soil respiration and its components to drought stress. *J. Soils Sediment*., 14: 99-109.

Yao, S.H., B. Zhang and F. Hu. 2011. Soil biophysical controls over rice straw decomposition and sequestration in soil: The effects of drying intensity and frequency of drying and wetting cycles. *Soil Biol. Biochem*., 43: 590-599.

Zhang, H., G.V. Johnson and M. Fram. 2002. Managing phosphorus from animal manure. Division of Agricultural Sciences and Natural Resources, Oklahoma State University.

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