INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
18–0952/2019/21–1–244–250
DOI: 10.17957/IJAB/15.0888
http://www.fspublishers.org

Full Length Article

Interactive Effects of Synthetic Fertilizer and Organic Residue Inputs on Soil Fertility and Wheat Crop under Various Moisture Regimes

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Abstract

Excessive use of chemical fertilizers causes nutrient losses, environmental pollution and reduced economic returns. Integrating organic resources with reduced dose of chemical fertilizers is important to release the nutrients fixed to soil colloids to improve and sustain soil fertility. In greenhouse and two-year field experiments, the effect of six different fertilizer treatments including control; recommended NPK; ½ NPK of recommended + mung bean straw; ½ NPK of recommended + rice straw; mung bean and rice straw under different water regimes was determined on soil fertility and wheat production. Fertilizer treatments caused remarkable increase in soil organic carbon (SOC), available nitrogen (AN), phosphorus (AP) and potassium (AK), wheat chlorophyll contents (Chl), dry biomass and grain yield, especially under 14 days of alternate wet dry cycles. Incorporation of mung bean straw resulted in increase of SOC, AN, AP, Chl and wheat dry biomass, while maximum increase in AK was observed with 200-150-100 kg NPK ha^{-1}. Highest C/N ratio and lowest soil pH were observed with rice straw. Maximum (up to 33%) increase in grain yield was achieved with 100-75-50 kg NPK ha^{-1} + mung bean straw during both years. In conclusion, alternate wet/dry cycles with integrated fertilizer options increased soil nutrients availability, wheat growth and yield. © 2019 Friends Science Publishers

Keywords: Integrated nutrient management; Organic amendments; Soil properties; Wet dry cycles; Wheat

Introduction

Wheat (*Triticum aestivum* L.) is one of the important cereal grain crop planted on more land than any other crop and staple food for more than one third of world's population (Asseng *et al.,* 2011). It is major contributor to ensure global food security being cheap source of about 50% caloric and 20% protein consumption of people in the poor countries of the world (Shiferaw *et al.,* 2013). Increasing demand of growing population for food compels to produce more grains than past per unit area. Application of mineral fertilizers has been increased mainly, because of sustainable crop production, increasing crop intensity and attentiveness about food quality. Continuous use of synthetic fertilizers and low use of organic matter has exhausted the soil fertility. Low soil fertility is one of the major constraints in limited wheat yield. High market cost, environmental concerns and less efficiency of sole use of inorganic fertilizers changed the farmer's trend towards use of organic amendments (NFDC, 2003). Excessive use of chemical fertilizers is reported to pollute air, soil and water resources, and quality of crop produce (Savci, 2012). Fertilizers may increase nitrate and phosphate amount in drinking water to harm health of living organisms. Use of organic material (*e.g.*, crop straw, compost and farm yard manure) has been suggested to improve to fertilizer use efficiency and soil fertility status (Gichangi *et al.,* 2009; Takeda *et al.,* 2009).

Addition of organic matter enhance the soil productivity by improving soil physico-chemical properties including nutrient availability, pH, water holding capacity, aggregate stability, cation exchange capacity and microbial activity (Clemente and Bernal, 2006; Agbede *et al.,* 2008; Muhammad and Khattak, 2009). However, nutrient bioavailability depends upon the decomposability and nutrient concentration of crop straw (Reddy *et al.,* 2005).

Drying and re-wetting has also been reported to significantly increase nutrient availability (Nguyen and Marschner, 2005). About 58% of total microbial biomass killed upon soil drying and re-wetting (Gastel *et al.,* 1993). Lysed microbial cells are the source of increase in water extractable organic P after soil drying. Upon re-wetting of dried soil some microbes will burst by the influx of water in cell while the others will be surviving by the efflux of solute to maintain the turgor pressure and involve in mineralization of organic compounds released by dead microbial biomass

To cite this paper: Farooq, N., M. Iqbal, M. Farooq and Z.A. Zahir, 2019. Interactive effects of synthetic fertilizer and organic residue inputs on soil fertility and wheat crop under various moisture regimes. *Intl. J. Agric. Biol.*, 21: 244–250

(Birch, 1958; Halverson *et al.,* 2000). Various legume crops and straws of exhaustive crops are preferred to incorporate in the soil for the maintenance of fertility status. Combined use of organic amendments along with drying re-wetting cycles caused a significant increase the nutrient availability (Macharia and Ekaya, 2002; Harrison-Kirk *et al*., 2013).

Organic matter status of most of the soils has reached to bare minimum (Aslam, 2016) and many scientists are threatening that moisture will decrease in most of the regions on earth during this century (Meehl *et al.,* 2007). Alteration on precipitation pattern could limit the availability of soil moisture during crop growing seasons (Austin *et al.,* 2004). The present studies were designed by keeping in mind the present scenario of low OM content and water crisis and solution of these defies by incorporation of crop straw instead of burning along with different moisture treatments.

Our hypothesis was that the effect of alternating wetting and drying would be more pronounced in the soil with high organic matter contents due to greater magnitude of biological effects. These studies were conducted to investigate the role of dry/wet cycles to enhance the nutrients availability in soil and to study the combined effect of crop straw and inorganic fertilizers along with dry/wet cycles on wheat growth and yield under laboratory and field conditions.

Material and Methods

Experiment 1. Comparative Effectiveness of Fertilizer, Crop Straw and their Interactions under different Water Regimes on Soil Fertility and Wheat Crop under Optimized Conditions

To evaluate the effect of dry/wet periods and different fertilizer treatments on soil fertility and growth of wheat crop, a control study was conducted at Soil Physics Laboratory, University of Agriculture, Faisalabad, Pakistan. The laboratory temperature was 20 to 25 ± 2ºC, 14 h photoperiod and relative humidity ranged from 28–55%. The experimental units (pots) were arranged in a completely randomized design with four replications. Pots were filled with sandy clay loam soil, air-dried, ground and sieved (2-mm 10-mesh^{-1}) for physico-chemical analysis of soil, soil properties are given in Table 1. In the first phase of experiment soil was pre-incubated at 60% of maximum WHC (water holding capacity) for 10 days at room temperature to activate the microbes. The moisture was maintained by weighing and adding the corresponding amount of water lost to evaporation on daily basis. In second phase crop straw referred as amendments were dried, ground and pass through 2 mm sieve. Six types of fertilizer treatments were applied including control; recommended NPK; ½ NPK of recommended + mung bean straw; ½ NPK of recommended + rice straw; mung bean and rice straw were mixed in soil prior to moisture treatments. Each pot was filled with experimental soil (0.35 kg) in PVC pots with 0.5 kg capacity. All the amendments were mixed uniformly.

Table 1: Physico-chemical properties of experimental soil

Characteristics	Units	Value
Sand	%	58
Silt	%	18
Clay	%	24
Textural Class	-	Sandy clay loam
Bulk density	Mg m^{-3}	1.58
Saturated hydraulic conductivity	X 10^{-4} cm S^{-1}	2.59
Organic matter	%	0.86
EC_e	dS m^{-1}	2.48
pH	-	7.9
Saturation percentage	%	35
Total nitrogen	%	0.04
Available phosphorous	mg kg^{-1}	8.82
Extractable potassium	mg kg^{-1}	129

Amendments (crop straw) were applied at a rate of 1 g^{-1} kg (1% on weight basis). Different moisture treatments including 28 M (28 d moist at 60% of WHC), 14 M (14 d moist then 14 d dry) and 28 D (28 d dry). All the pots were incubated at an average room temperature.

In 2nd phase, 28 d after amendment and moisture treatment application, all the pots were brought at 60% water holding capacity and were maintained at this moisture level for up to 53 days. Wheat seeds were pre-soaked and eight pre-germinated seeds sown in each pot and four plants per pot were maintained after thinning. Wheat plants were harvested after 25 days of transplanting.

Soil organic carbon was measured by a K_2CrO_7-H_2SO_4 oxidation procedure. Soil C/N values were calculated as the ratio of soil organic carbon to total nitrogen. Available soil inorganic N was determined as the sum of NO_3-N and NH_4 -N in filtered 2 *M* KCl extracts. Available phosphorus was determined by the Olsen method (Olsen *et al.,* 1954). Available potassium was measured by flame photometry after NH_4OAc neutral extraction (Richards, 1954). Wheat chlorophyll contents in the form of SPAD value of flag leaf were measured prior to harvesting using chlorophyll meter (Minolta SPAD 502 Meter). Repeated experiment gave statistically similar results therefore pooled data were used for statistical analysis.

Experiment 2. Comparative Effectiveness of NPK Fertilizer, Crop Straw and their Interactions on Soil Fertility and Wheat Crop under Field Conditions

Site description: Two-year field studies were conducted at Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan (latitude 31º26'N and 73º06'E, altitude 185 m above mean sea level), during 2014–2015 and 2015–2016. Field vacated after rice crop was selected for this study and the physico-chemical characteristics of experimental soil are given in Table 1. Faisalabad climate has semi-arid features with mean winter rain-fall and relative humidity about 10–15 mm and 60%, respectively.

Table 2: Weather data during the course of studies

Months	Average temperature (°C)				Total rainfall (mm)		Average relative humidity (%)		Daily Sunshine (h)	
	Maximum		Minimum							
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
November	26.3	27.1	11.5	12.1	10	8.8	61.7	61.5	7.6	6.6
December	18.5	21.8	5.9	7.2	0	0	75.0	62.6	4.7	7.0
January	16.6	17.3	6.9	7.7	12.2	13.1	75.3	74.4	5.0	3.5
February	22.0	23.3	11.1	9.3	20.5	7.8	66.0	58.1	5.6	8.5
March	24.5	34.3	13.6	20.2	67.9	5.6	64.0	34.2	4.9	8.0

Source: Agricultural Meteorological Cell, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan

During both years, weather data were obtained from Agricultural Meteorological Cell, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan (Table 2).

Experimental details: For seedbed preparation field was cultivated thrice with a tractor mounted plough followed by planking each time. Wheat variety (cv. Glaxy-2013) was sown at 22.50 cm row spacing with manual drill using 125 kg ha^{-1} seed rate on 20 November in 2014 and 16 November in 2015. Before sowing, the seed was soaked in water for 12 h to facilitate better germination. All other agronomic practices were followed as per recommendations. Recommended fertilizers doses for field of study were 200-150-100 kg NPK ha^{-1} were applied in the form of urea (46% N), diammonium phosphate (46% P_2O_5 and 18% N) and sulfate of potash (50% K_2O). Six types of fertilizer treatments including control; recommended NPK; ½ NPK of recommended + mung bean straw; ½ NPK of recommended + rice straw; mung bean and rice straw were mixed in soil prior to moisture treatments. Nitrogen (N) fertilizer were applied in three splits, however, whole dose of phosphorus (P), potassium (K) and crop straw treatments were applied just prior to moisture treatment. The mung bean and rice straw were applied at 8 t ha^{-1}. Before application, mung beans and rice straw were chopped in to small pieces (3–5 cm) to facilitate incorporation in the soil and decomposition. Field was kept under alternate wetting and drying (14 M; that gave best results under controlled studies) for 28 days before wheat planting. Weeds were kept under economic threshold level by using herbicides. All other practices except those under study were kept uniform for all treatments. Crop was harvested at full maturity on 22th April, 2015 and 7th April, 2016.

Experimental design, observations and statistical analyses: Experiment was conducted under randomized complete block design with four replications under factorial arrangement. Data regarding soil organic carbon and soil available nutrients including NPK and wheat chlorophyll contents were collected using same procedure described in pot studies. Wheat grain yield was determined from each plot (6 m x 2.25 m) by harvesting them separately and converted to t ha^{-1}.

Data for both pots and field studies were collected separately from each experimental unit and collected data were subjected to Fisher's analysis of variance and means were compared using Tukey's HSD test at the 5% probability level (Statistix 8.1, Analytical software, Statistix; Tallahassee, FL, USA, 1985–2003). Statistical analyses revealed significant year effect therefore data are described separately for both years.

Results

Soil Organic Carbon and Nutrient Status of Soil under Controlled Conditions

Significant interactive effect of fertilizer treatments and wet/dry cycles revealed that maximum increase (67%) in organic carbon contents was observed in pots treated with sole mung bean straw along with alternate wetting and drying at 14 days interval (14 M) as compared to control (Table 3). It was followed by rice straw treatment at the same moisture level. Interactive effect of different fertilizer treatments and wet/dry cycles was significant regarding soil available N, P and K. Wetting and drying events showed more increase in N, P and K contents as compared to treatments applied with constantly wet (28 M) and dry conditions (28 D). There were 46 and 43% increase in available N in mung bean straw and rice straw respectively as compared to control at 14 M.

Leaf Chlorophyll Content and Dry Biomass of Wheat under Controlled Conditions

Different treatments of fertilizers plus organic amendments along with wet/dry cycles showed significant interactive effect regarding chlorophyll contents and dry biomass of wheat. Fourteen days alternate dry and wet interval (14 M) caused more increase in chlorophyll contents (0.54–1.17 mg g^{-1}), whereas 28 days wet (28 M) and 28 days dry (28 D) had 0.43–84 mg g^{-1} and 0.45–0.81 mg g^{-1} respectively (Table 4).

Soil Organic Carbon and Nutrient Status of Soil under Field Conditions

Significant interactive effect of fertilizer treatments revealed maximum increase (59–63%) in organic carbon contents in

Table 3: Effects of different synesthetic fertilizer and organic amendments 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})		
	28 M	14 M	28 D	28 M	14 M	28 D	28 M	14 M	28 D	28 M	14 M	28 D
Control	7.45±0.50ij	7.57±0.75h-j	6.57±1.0j	69±2.50hi	76±2.75g-i	64±3.0i	10±1.75g-i	09±1.3hi	07±1.25i	17±6.5k	20±6.0i-k	18±5.25jk
NPK	11.41±1.80fg	12.1±1.33e-g	10.23±0.77g-i	93±6.30e-g	103±4.75d-f	85±5.0f-i	14±4.89g	25±5.75cd	12±3.15gh	45±6.23ab	48±5.75a	41±4.85-c
½ NPK + mung bean straw	10.83±0.65fg	12.83±0.90d-g	10.45±1.5gh	91±6.0e-h	129±5.5a-c	90 ± 4.0e-h	20±5.0ef	28±4.85c	22±4.0d-f	35±5.85cd	40±5.0bc	28±4.9e-h
½NPK+rice straw	12.07±1.65e-g	13.07±1.35d-g	11.35±1.28fg	80±2.80g-i	118±3.75b-d	94±4.25e-g	20±3.75ef	33±4.15b	19±3.25f	33±4.75de	35±4-d	31±5.64d-g
Mung bean straw	16.34±1.0bc	20.87±0.80a	14.43±1.75b-e	85±3.35f-i	142±4.75a	112±5.25c-e	28±4.5c	40±3.85a	25±4.75cd	26±4.25f-i	30±6.3d-h	24±5.78h-j
Rice straw	15.17±1.38b-d	16.67±1.48b	13.67±1.62c-f	78±4.15g-i	135±5.15ab	103±5.75d-f	22±5.25d-f	35±5.5b	24±4.85c-e	24±4.0h-j	32±6.45d-f	25±5.10g-i

28 M: 28 days moist at 60% of WHC, 14 M: 14 days moist then 14 days dry and 28 D: 28 days dry. The means sharing same letters, within a column, do not differed significantly at $p \leq 0.05$. The values are means ± standard error

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

Treatments	Chlorophyll contents (SPAD)			Dry biomass (g/pots)		
	28 M	14 M	28 D	28 M	14 M	28 D
Control	40.2 ± 0.11i	41.3 ± 0.2hi	38.1 ± 0.15j	0.80 ± 0.12g	0.85 ± 0.13g	0.78 ± 0.45g
NPK	46.2 ± 0.23b-d	54 ± 0.16a	46.5 ± 0.20c-e	1.65 ± 0.5a-d	1.71 ± 0.35a-c	1.57 ± 0.23a-f
½ NPK + mung bean straw	45.2 ± 0.21d-f	51 ± 0.13b	45.1 ± 0.19d-f	1.60 ± 0.4a-e	1.75 ± 0.15ab	1.54 ± 0.6a-f
½ NPK + rice straw	43.8 ± 0.18e-h	0.88 ± 0.22b-d	44.9 ± 0.12de-g	1.55 ± 0.34a-f	1.75 ± 0.4ab	1.50 ± 0.39b-f
Mung bean straw	44.9 ± 0.13e-h	48.2 ± 0.17bc	44.8 ± 0.16f-h	1.40 ± 0.13c-f	1.85 ± 0.15 a	1.30 ± 0.19ef
Rice straw	44.2 ± 0.19f-h	47 ± 0.21b-d	43.6 ± 0.18g-I	1.32 ± 0.32d-f	1.80 ± 0.39 ab	1.25 ± 0.48f

28 M: 28 days moist at 60% of WHC, 14 M: 14 days moist then 14 days dry and 28 D: 28 days dry. 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
Control	7.54 ± 0.53f	8.07 ± 1.0f	65 ± 3.21d	73 ± 3.0e	05 ± 0.21d	07 ± 0.25d	16 ± 1.21e	19 ± 1.5d
NPK	9.82 ± 2.03e	10.21 ± 1.75e	97 ± 5.50c	96 ± 5.25d	19 ± 3.11c	23 ± 3.0c	39 ± 3.76a	41 ± 3.5a
½ NPK + mung bean straw	14.83 ± 0.75c	14.65 ± 1.5d	109 ± 4.5b	117 ± 4.0c	25 ± 2.5b	31 ± 2.75b	31 ± 3.15b	35 ± 1.8b
½ NPK + rice straw	12.07 ± 1.90d	16.34 ± 1.45c	104 ± 3.45b	101 ± 3.5d	27 ± 1.75b	29 ± 1.5b	32 ± 3.25b	33 ± 3b
Mung bean straw	18.54 ± 1.65a	21.67 ± 1.85a	115 ± 3.75a	139 ± 3.25a	31 ± 2.25a	37 ± 1.9a	20 ± 2.75d	26 ± 3.25c
Rice straw	16.43 ± 0.93b	18.54 ± 1.95b	95 ± 5.0c	125 ± 4.20b	26 ± 2.85b	30 ± 1.45b	23 ± 1.75c	25 ± 2.5c

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

plots treated with sole mungbean straw that was followed by rice straw treatment in both year of studies (2014–2015 and 2015–2016) (Table 5).

Application of mung bean straw showed an increase in N (65–115, 73–139 mg kg^{-1}) and P (5–31, 7–37 mg kg^{-1}) contents in the year of 2014–2015 and 2015–2016 respectively. However, high K (16–39, 19–41 mg kg^{-1}) contents were observed in recommended NPK in both year of studies (Table 5).

C/N Ratio and Soil pH under Field Conditions

Interactive effect of fertilizer treatments and wet/dry cycles was significant regarding C/N ratio and soil pH gradient. Among fertilizer treatments, rice straw showed high C/N ratio as compared to all other treatments. Low C/N was observed with application of mung bean straw 8 t ha^{-1} which was followed by ½ recommended NPK + ½ mung bean and ½ recommended NPK+ ½ rice straw. More increase in soil pH was observed with application of recommended NPK. 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 and ½ recommended NPK+ ½ rice straw (Fig. 1).

Leaf Chlorophyll Contents and Wheat Grain Yield under Field Conditions

Different treatments of fertilizer plus organic amendments showed significant interactive effect regarding chlorophyll content and wheat grain yield in both year of studies. Application of recommended NPK caused maximum increase in chlorophyll content in the year of 2014–2015. While ½ recommended NPK and mung bean showed high chlorophyll content during 2015–2016. Application of ½ recommended NPK and mung bean straw caused maximum increase in grain yield (30% and 33% as compared to control) during 2014–2015 and 2015–2016, respectively (Table 6).

Discussion

Soil available P significantly varied in all wet/dry (14 M) cycles particularly with incorporation of mung bean

Table 6: Effects of different fertilizer plus organic amendments treatments on chlorophyll contents and grain yield of wheat at maturity during 2014–15 and 2015–16

Treatments	Chlorophyll contents (SPAD)		Wheat grain yield (t ha^{-1})	
	2014-15	2015-16	2014-15	2015-16
Control	31.2 ± 0.11d	29.4.4 ± 0.21e	3.85 ± 0.32f	3.92 ± 0.35f
NPK	49.5 ± 0.23a	48.1 ± 0.14b	5.33 ± 0.65b	5.27 ± 0.61b
½ NPK + mung bean straw	48.7 ± 0.18b	49.3 ± 0.20a	5.55 ± 0.60a	5.57 ± 0.55a
½ NPK + rice straw	47.6 ± 0.13b	46.3 ± 0.10c	4.95 ± 0.35c	5.25 ± 0.40c
Mung bean straw	46.2 ± 0.19c	45.6 ± 0.22c	4.57 ± 0.49d	4.67 ± 0.49d
Rice straw	45.9 ± 0.17c	42.6 ± 0.15d	4.31 ± 0.55e	4.52 ± 0.6e

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

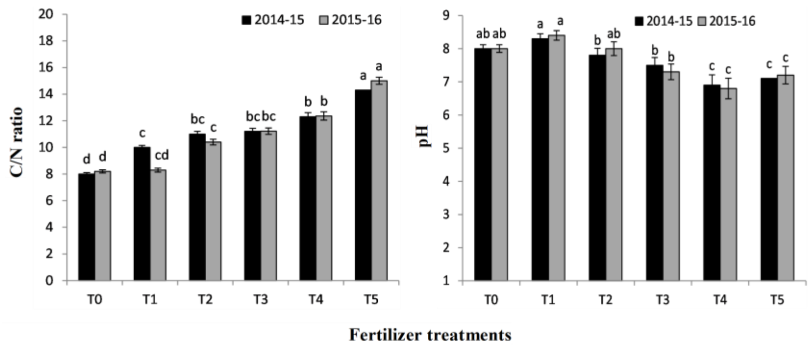

Fig. 1: Effect of various fertilizer treatments on C/N ratio and soil pH during 2014-15 and 2015-16. To: control, T1: 200-15-100 Kg NPK ha-1, T2: 100-75-50 Kg NPK ha-1 + mung bean straw 4 t ha^{-1}, T_3: 100-75-50 Kg NPK ha^{-1} + rice straw 4 t ha^{-1}, T_4: mung bean straw 8 t ha^{-1} and T_5: Rice straw8 t ha^{-1}. Bars indicate standard error of mean. Means with different letters are significantly different from each other at the 95% confidence level

and rice straw along with 14 M 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 (Hussain *et al.,* 2003). Slow release P form sources that release P to soil solution in smaller but frequent concentrations increase the nutrient availability for crop and reduce the fixation process (Hussain *et al.,* 2003). Similar findings have also been reported by Nash *et al.* (2005), Wandruszka (2006). It was revealed that addition of organic sources of fertilizers caused significant increase in available P contents due to their effects on mobilization of soil P and releasing of P after decomposition of organic sources.

In this experiment, increased N content after soil drying and re-wetting are supported by Grootjans *et al.* (1986). The 14 days alternate wetting and dry (14 M) leads to high N content as compared to soil with constant moisture content. Nitrogen mineralization rate in our studies fall in the range within similar as 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 and 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) (Partey *et al.,* 2014). However, incorporation of crop residues into the soil and its subsequent decomposition replenishes the soil organic matter content, but it also supplies essential nutrients after mineralization (Maurya and Lal, 1981).

Leaf chlorophyll contents are important indicator of wheat crop health and growth to ensure higher yield (Zhang *et al.,* 2016). In present study, chlorophyll contents significantly increased with 14 M moisture treatment along with different inorganic and organic fertilizer treatments. High chlorophyll content are the reason of increase available nutrient content for wheat, treatments caused increase in available nutrients in soil produced more chlorophyll content in wheat. Bojovic and Markovic (2009) reported a strong correlation between available content and chlorophyll content of plant. Furthermore, Amujoyegbe *et al.* (2007) reported more increase in of chlorophyll contents with organic fertilizer application as compared to inorganic NPK applications, which concept is diverging to the present studies where inorganic fertilizer treatment also showed good results along 14 D moisture treatment.

There was high biomass production of wheat in mungbean straw treated plot with 14 D 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. Increase in wheat production might be the reason of high nutrients availability and uptake by crop. reported that bacterial cell lysis results in increase nutrients in soil and potentially important source of plant available P.

In this study, more wheat grain yield was achieved with the application of ½ NPK plus mung bean straw, Ghosh *et al.* (2004) noticed a considerable increase in yield after the combined application of NPK and organic fertilizers as compared to sole application of inorganic fertilizer. Buneman *et al.* (2013) also observed high wheat yield after organic fertilizer application. More grain yield achieved with addition of low C/N ratio straw as low C/N ratio straw can supply more N to plants during the grain filling period (Kamkar *et al.* (2014). Increase in wheat grain yield was due 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).

Conclusion

Alternate wet/dry cycles have significant role in enhancing the potential integrated effect of rice or mung bean straw and inorganic fertilizers to improve soil and wheat yield as compared to permanent wet or dry durations. Sole application of either crop-straw or inorganic fertilizers was less effect than their integrated use.

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(Received 07 July 2018; Accepted 05 September 2018)