The Journal of Animal & Plant Sciences, 28(4): 2018, Page: 1112-1120
ISSN: 1018-7081

COMBINED APPLICATION OF DISTILLERY SPENT WASH, BIO-COMPOST AND INORGANIC FERTILIZERS IMPROVES GROWTH, YIELD AND QUALITY OF WHEAT

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ABSTRACT

The combined application of organic and inorganic fertilizer improves crop productivity and soil health. The field experiments were conducted to determine the effect of distillery spent wash (DS), bio-compost (BC) and NPK fertilizers on growth, yield and quality of wheat crop during 2013-14 and 2014-15 at Shakarganj Sugar Research Institute (SSRI) Jhang, Pakistan. The experiment was laid out in randomized complete design and composed of different combination of DS, BC and NPK i.e., T_1: DS 0%+ BC 0% + F 0%, T_2: DS 50% (64m^3) + BC 50% (450kg ha^{-1}) + F 0%, T_3: DS 50% + BC 50% (450kg ha^{-1}) + F 25% (30-25-15 NPK kg ha^{-1}), T_4: DS 25% (32 m^3) + BC 25% (225kg ha^{-1}) + F 50% (60-50-30 NPK kg ha^{-1}), T_5: DS 50 % (64m^3) + BC 25 % (225kg ha^{-1}) + F 25 % (30-25-15 NPK kg ha^{-1}), T_6: DS 25% (32 m^3) + BC 50% (450kg ha^{-1}) + F 25% (30-25-15 NPK kg ha^{-1}). The maximum improvement in growth attributes were recorded in treatment T_4, whereas, the minimum values of growth attributes were found in control treatment. The maximum plant height (107 cm, 106.2 cm), productive tillers (427.50, 424.25), 1000 grain weight (37 g, 37.75 g) grain yield (5.15 t ha^{-1}, 4.96 t ha^{-1}) and biological yield (10.28 t ha^{-1}, 10.14 t ha^{-1}) were recorded in treatment T_4 while the minimum values of these attributes were obtained without use of DS, BC and NPK. Moreover, maximum grain nitrogen, phosphorus, potassium and protein contents were also found in treatment T_4 whereas no application of DS, BC and NPK significantly reduced these qualitative attributes. These results suggested that combination of [(DS 25% (32 m^3)+BC 25% (225kg ha^{-1})+F 50% (60-50-30 NPK kg ha^{-1})] can be used to improve growth, yield and quality of wheat.

Keywords: Wheat, Bio-compost, Distillery spent wash, NPK, Growth, Yield, Quality.

INTRODUCTION

Wheat is second major cereal grown globally, additionally; it is a staple food of many countries including Pakistan. In Pakistan wheat has a major role in supplying calories and nutrients; on the other side it also had a share of 10.1% in value addition of agriculture and 2.11% in national GDP (Govt. of Pakistan, 2016). Although, Pakistan has self sufficiency in production of wheat, however, the average yield of Pakistan is quite low than the developed nations (FAOSTAT, 2011). There are many factors which are responsible for the lower yield of wheat crop in Pakistan, among these the most important ones are; heavy infestation of weeds, poor soil fertility and imbalanced fertilizer application (Ali *et al*., 2005). To enhance the agricultural productivity, plant nutrients play an important role. Due to more intensive and exploitative agriculture, nutrient deficiencies are becoming serious (Savithri *et al.,* 1999).

The cultivation of exhaustive crops, poor soil management and imbalanced fertilizers application significantly limits the crop yield (Gholve *et al.*, 2001). Likewise, blooming prices (Khandagave, 2003) and unavailability of fertilizers during the peak season of crop growth also limits the crop productivity (Sarwar *et al.,* 2008). The continuous use of in inorganic fertilizers also deteriorates the soil health, thus it is mandatory to use alternate sources that would increase the crop productivity and soil health (Rodriguez, 2000). Integrated nutrient management has proved beneficial for improving the soil health and crop productivity on sustainable basis. Integrated nutrient management can be achieved through managing the nutrients from all possible nutrients sources, including compost, green manuring crops, animal manures, plant residues, industrial waste, sewage sludge and inorganic fertilizers (Singh *et al.,* 2002). The combined application of nutrients not only fulfils the plant needs but also ensures the soil health, productivity with additional benefits of environmental protection (Ghaffar *et al.,* 2011).

In Pakistan, many industries are using agricultural produced as a raw material and continuously producing different types of materials. Sugar industry is one of the major industries in Pakistan, which generates huge amount of by-products, like press mud, bagasse, distillery spent wash (DS) and bio-compost (BC). These by-products could cater the needs of field crops and can be good alternate of inorganic fertilizers.

DS and BC contains huge amount of nutrients, both these products not only improve the crop yield but also ameliorate the soil health (Jamil *et al.,* 2008).

Several researchers reported the beneficial effects of conjunctive use of BS, DS and synthetic fertilizers on soil health, crop yield and nutrient uptake than the alone use of synthetic fertilizers (Chand *et al.,* 2006). Likewise, Nawaz *et al.,* (2017) reported that BC and NPK fertilizers considerably improved the growth, yield as well as the quality of sugarcane crop. Similarly, Sarwar *et al.* (2008) also noticed the beneficial effects of combined application of inorganic fertilizers and BC on the crop growth and yield. The application of DS, significantly, increased the cane and sugar yield and decreased the demand of chemical fertilizers (Rath *et al.,* 2011). Similarly, Sharma (2013) found the significant influence of DS and synthetic fertilizers on yield and chlorophyll concentration of pea plants. Moreover, the application of diluted DS on course textured sandy and calcareous soils increased the water holding capacity, nutrient holding capacities, availability of macro and micronutrients (Rath *et al.,* 2011).

Spiraling prices and unavailability of fertilizers during the peak season not only limits the wheat productivity, but also raise contradict concerns in recommendation of proper dose in wheat. Realizing the importance of sugar mills by-products as another source of plant nutrients that reduce the fertilizer dose for crops and its being disposal and management to clean the environment, an attempt has been made to determine the suitable combination of organic and inorganic fertilizers on growth, yield and quality of wheat.

MATERIALS AND METHODS

Study site and experimental design: The field trials were conducted at Shakarganj Sugar Research Institute (SSRI) Jhang, Pakistan during 2013-14 and 2014-15 (longitude 73.8°E, latitude 31.8°N, and altitude 184.4 masl). The study site comes under semi-arid region (Chattha *et al.,* 2017). Furthermore the prevailed conditions during both growing seasons are given in Fig 1. The composite soil samples were taken from the depth of 30 cm during both the years from study site in order to determine various physical and chemical properties. The soil was sandy loam and had sand (43.86%), silt (36.11%) and clay contents (20.03%). In addition, soil averagely has pH (7.85), Ec (1.74 dS m^{-1}) and containing organic matter (0.72%), nitrogen (0.043%), phosphorus (4.63 ppm) and potassium (121 ppm). The study was conducted in randomized complete block design having four replicates.

Experimental treatments: The experiments were comprised of six various combinations of distillery spent wash (DS), bio-compost (BC) and NPK fertilizer (F) levels Table 1.

Crop Husbandry: After harvesting of rice crop the seed bed was prepared by ploughing the field three times followed by planking. The wheat crop was sown on 7th November, 2013 and 10th November, 2014 using hand drill by maintaining the 23 cm row to row distance. Seed was used at the rate of 125 kg ha^{-1}. Combinations of DS, BC and F were applied as per treatment with first irrigation. During both the years, four irrigations were applied to wheat crop. All the other management practices including, weed management, disease management and insect control were kept uniform throughout the growing seasons. Crop was harvested manually on 10th and 15th May, during 2013 and 2014 respectively.

Data collection and variable measurements: Number of emerged seeds were counted on daily basis from specific area of one square meter. Leaf area was measured by leaf area meter (Model: Licor 3000), whereas the leaf area index (LAI) was measured by the standard procedures of Watson, (1947). LAI was measured seven times during crop growth period each year, first LAI was measured after 30 days of sowing and then after 15 days of interval up to 120 days after sowing and later on the average of all the LAI was calculated. Similarly, leaf area duration (LAD) and crop growth rate (CRG) were measured by standard methods of Hunt, (1978). Likewise, first LAD and CGR were taken post 30 days of sowing and there after 15 days of interval up to 120 days after sowing and later on the average of all the LAD and CGR were calculated. At maturity, twenty plants were taken randomly to determine the plant height, whereas the ten spikes were chosen randomly to determine the spike length, grains per spike and spikelets per spike. A sub sample of seeds was taken to determine the 1000-grain weight. The whole plots were harvested to determine the grain and biological yield and later on converted mathematically into ton per hectare basis. The grain samples were dried in oven and later on grinded with the help of grinder. The grain protein contents were determined by the standard procedures of AOAC (1990), whereas, grain nitrogen and phosphorus was measured by standard procedure of Olsen *et al.* (1954) and Chapman and Parker, 1961) respectively. Similarly the grain potassium content was measured by using flame photometer from the standard curve (Yaseen *et al.,* 2015).

Statistical analysis: The collected data were analyzed by Statistics 8.1 software, while the differences among the treatments were compared by applying least significant difference test at 5% probability level. The graphs were generated by using sigma plot software 8.

RESULTS

Results revealed that different levels of DS, BC and NPK remarkably affected the growth, yield and quality of wheat except germination count during both the years. The maximum improvement in LAI, LAD and

CGR during both years was recorded with the application of [(DS 25% (32 m^3) + BC 25% (225 kg ha^{-1}) + F 50% (60-50-30 NPK kg ha^{-1})], however, it was at par with [DS 50% + BC 50% (450 kg ha^{-1}) + F 25% (30-25-15 NPK kg ha^{-1})], whereas the minimum improvement in growth attributes was recorded without application of organic and inorganic fertilizers (Fig 2).

Similarly, results also revealed that different combinations of distillery spent wash, bio-compost and inorganic fertilizers markedly improved yield attributes of wheat (Table 2 and 3). The maximum plant height (112 cm and 109.5 cm) and productive tillers (427.50 and 424.25) during both the years were obtained with the combined application of [(DS 25% (32 m^3) + BC 25% (225kg ha^{-1}) + F 50% (60-50-30 NPK kg ha^{-1})], which were similar to [DS 50% + BC 50% (450 kg ha^{-1}) + F 25% (30-25-15 NPK kg ha^{-1})], whereas the minimum plant height (75 cm, 71.2 cm) and productive tillers (335 cm, 300.91 cm) were recorded with no application of distillery spent wash, bio-compost and inorganic fertilizers.

The application of organic amendments and NPK fertilizer, remarkably improved the grains per spike and 1000 grain weight (Table 2, 3). However the maximum grains per spike (48, 47.25) and 1000 grain weight (34.75g, 35g) were recorded with [(DS 25% (32 m^3) + BC 25% (225 kg ha^{-1}) + F 50% (60-50-30 NPK kg ha^{-1})], that was similar to [DS 50% + BC 50% (450kg ha^{-1}) + F 25% (30-25-15 NPK kg ha^{-1})], where as no app nlication of organic fertilizer sources and inorganic fertilizers considerably reduced the both the grains per spike and 1000 grain weight (Table 1, 2). The application of distillery spent wash, bio-compost and inorganic fertilizers also had the significant effect on the grain yield, biological yield and harvest index (Table 3). The maximum grain yield (51.5 t ha^{-1}, 4.96 t ha^{-1}) and biological yield (10.28 t ha^{-1}, , 10.14 t ha^{-1}) were obtained with the application of [(DS 25% (32 m^3) + BC 25% (225kg ha^{-1}) + F 50% (60-50-30 NPK kg ha^{-1})], whereas the minimum grain yield (2.35 t ha^{-1}, 2.32 t ha^{-1}) and biological yield (5.45 t ha^{-1}, 5.53 t ha^{-1}) were obtained without application of any fertilizers sources (Table 3). Similarly, maximum value of harvest index (0.50%, 0.49%) were recorded with [(DS 25% (32 m^3) + BC 25% (225kg ha^{-1}) + F 50% (60-50-30 NPK kg ha^{-1})], that were comparable with all the treatments except the control (Table 3).

The application of different combinations of organic sources and inorganic fertilizers had considerable effect on the all the tested qualitative attributes except grain oil percentage (Fig 3, 4). The maximum grain nitrogen, phosphorus and potassium contents were recorded with the use of [(DS 25% (32 m^3) + BC 25% (225 kg ha^{-1}) + F 50% (60-50-30 NPK kg ha^{-1})], that was comparable with [DS 50% + BC 50% (450 kg ha^{-1}) + F 25% (30-25-15 NPK kg ha^{-1})], however, the minimum grain nitrogen, phosphorus and potassium contents were obtained with the application of spent wash, bio-compost and inorganic fertilizers (Fig 3). Similarly, application of various combinations of organic sources and inorganic fertilizers remarkably improved grain protein concentration, while had non-significant effects on the grain oil concentration (Fig 4). The maximum grain protein percentage was recorded with application of [(DS 25% (32 m^3) + BC 25% (225 kg ha^{-1}) + F 50% (60-50-30 NPK kg ha^{-1})], whereas the lowest grain protein percentage was recorded without the application of organic sources and inorganic fertilizers (Fig 4).

Table 1. Treatment combinations used in study.

Treatments	Description
T_1	DS 0%+ BC 0% + F 0% (Control)
T_2	DS 50% (64 m^3) + BC 50% (450 kg ha^{-1}) + F 0%
T_3	DS 50% + BC 50% (450 kg ha^{-1}) + F 25% (30-25-15 NPK kg ha^{-1})
T_4	DS 25% (32 m^3) + BC 25% (225 kg ha^{-1}) + F 50% (60-50-30 NPK kg ha^{-1})
T_5	DS 50% (64 m^3) + BC 25% (225 kg ha^{-1}) + F 25% (30-25-15 NPK kg ha^{-1})
T_6	DS 25% (32 m^3) + BC 50% (450 kg ha^{-1}) + F 25% (30-25-15 NPK kg ha^{-1})

Table 2. Influence of distillery spent wash, bio-compost and NPK fertilizers levels on germination plant height, tillers m^{-2} and grains per spike of wheat crop

Treatments	Germination count (m^{-2})		Plant height (cm)		Total tillers (m^{-2})		Grains per spike	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T_1	204	203	75.0c	71.2c	335.0c	300.95c	29.50d	29.50c
T_2	206	205	107.0b	106.2b	377.50b	359.25b	45.00bc	45.25b
T_3	205	204	111.0a	108.5a	423.0a	410.00a	47.00ab	47.00a
T_4	203	205	112.0a	109.5a	427.50a	424.25a	47.25a	48.00a
T_5	204	203	108.0b	106.5b	370.0 bc	340.50b	44.25c	44.75b
T_6	203	204	108.5b	105.5b	350.0 bc	337.25b	43.25c	43.75b
LSD ($p \leq 0.05$)	**NS**	**NS**	**1.76**	**1.96**	**31.37**	**35.94**	**2.22**	**1.51**

In column means sharing different letters differ significantly at $p \leq 0.05$. NS = non-significant

Table 3. Influence of distillery spent wash, bio-compost and fertilizer (NPK) levels on 1000 grain weight, grain yield, biological yield and harvest index of wheat crop.

Treatments	1000-grain weight (g)		Grain yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index (%)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T_1	33.50c	33.00c	2.35c	2.32c	5.45c	5.53c	0.43b	0.42b
T_2	34.75bc	35.00b	4.28b	4.16b	8.71b	8.61b	0.49a	0.48a
T_3	36.75a	37.25a	5.00a	4.95a	10.10a	10.12a	0.49a	0.49a
T_4	37.00a	37.75a	5.15a	4.96a	10.28a	10.14a	0.50a	0.49a
T_5	35.00b	35.00 b	4.25b	4.02b	8.65b	8.57 b	0.49a	0.46a
T_6	34.50bc	34.75b	4.17b	4.08b	8.72b	8.56b	0.48a	0.47a
LSD ($p \leq 0.05$)	**1.43**	**1.54**	**0.17**	**0.19**	**0.40**	**0.36**	**0.02**	**0.02**

In column means sharing different letters differ significantly at $p \leq 0.05$. NS = non-significant

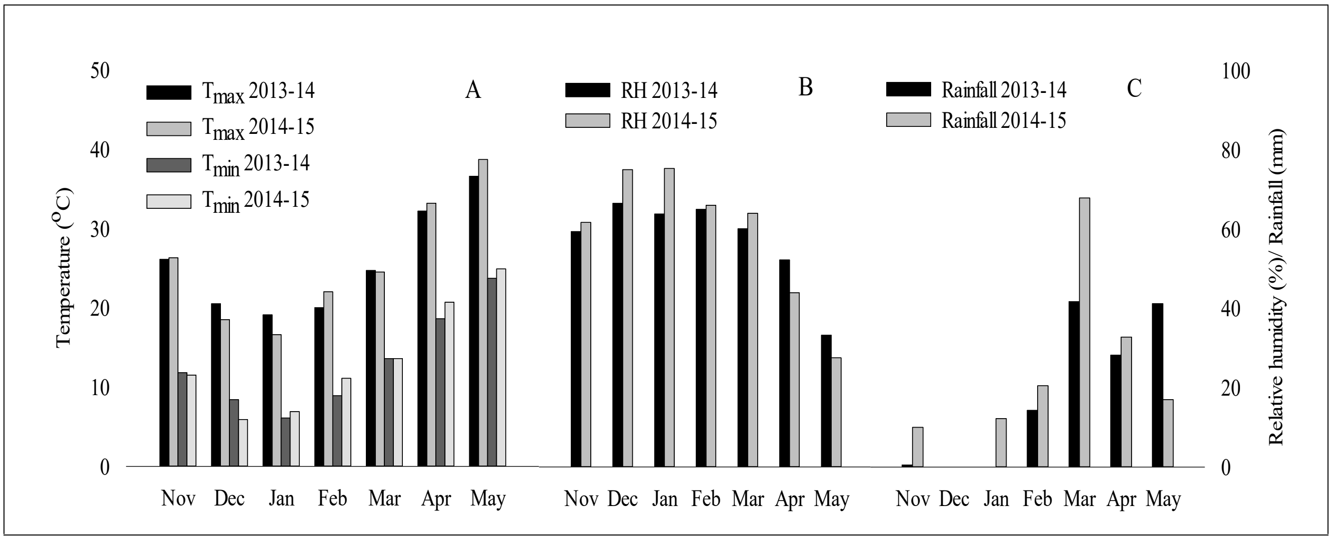
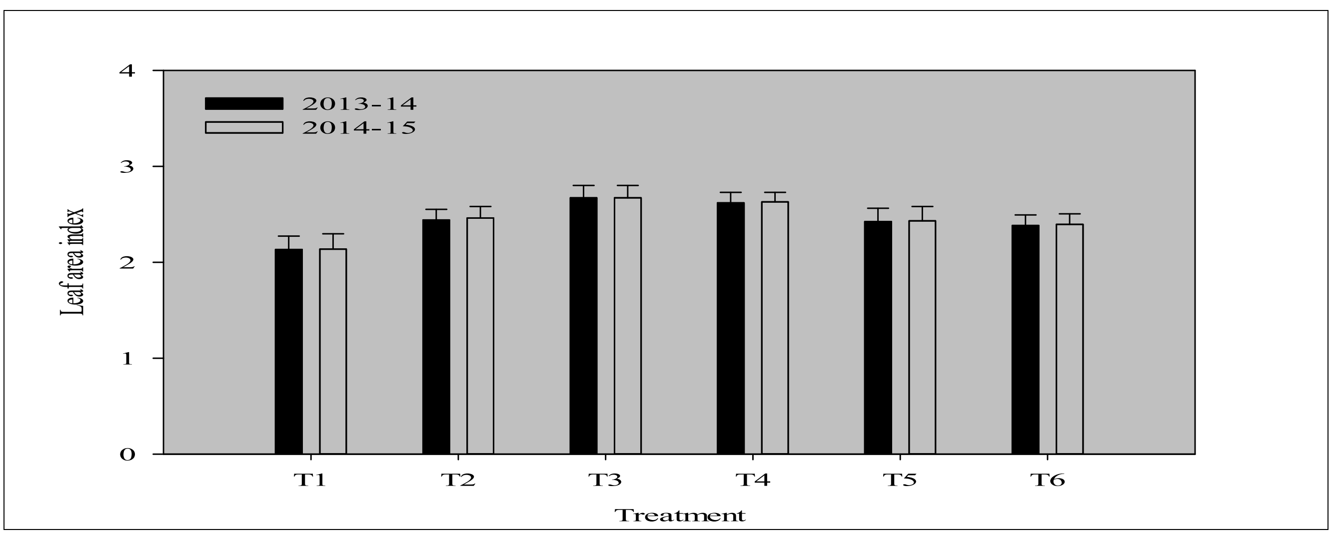


Fig.1 Prevailed climatic conditions for both years during the growing seasons. A: Mean monthly, maximum, minimum and average temperature, B: Mean monthly relative humidity, C: Monthly rain fall.



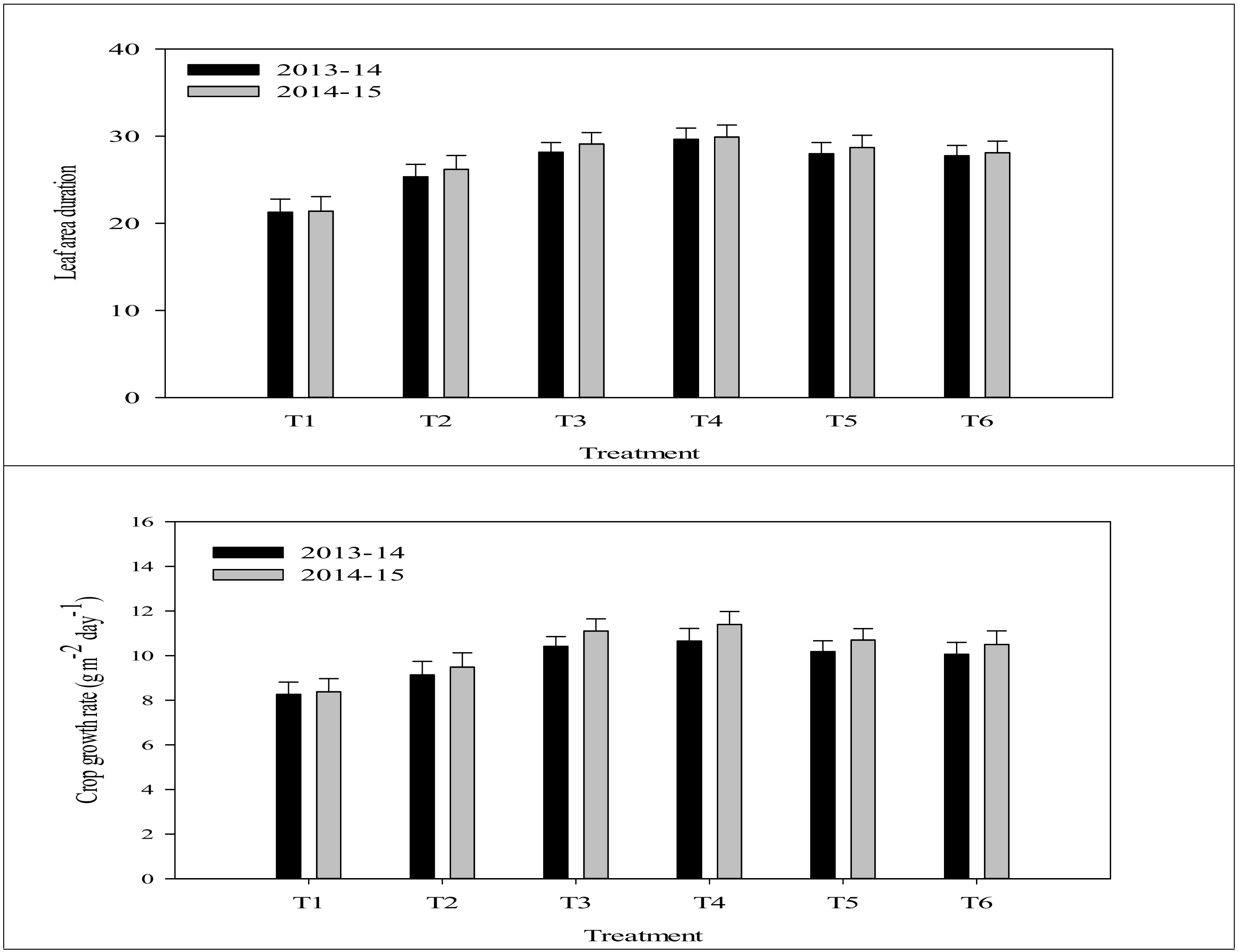
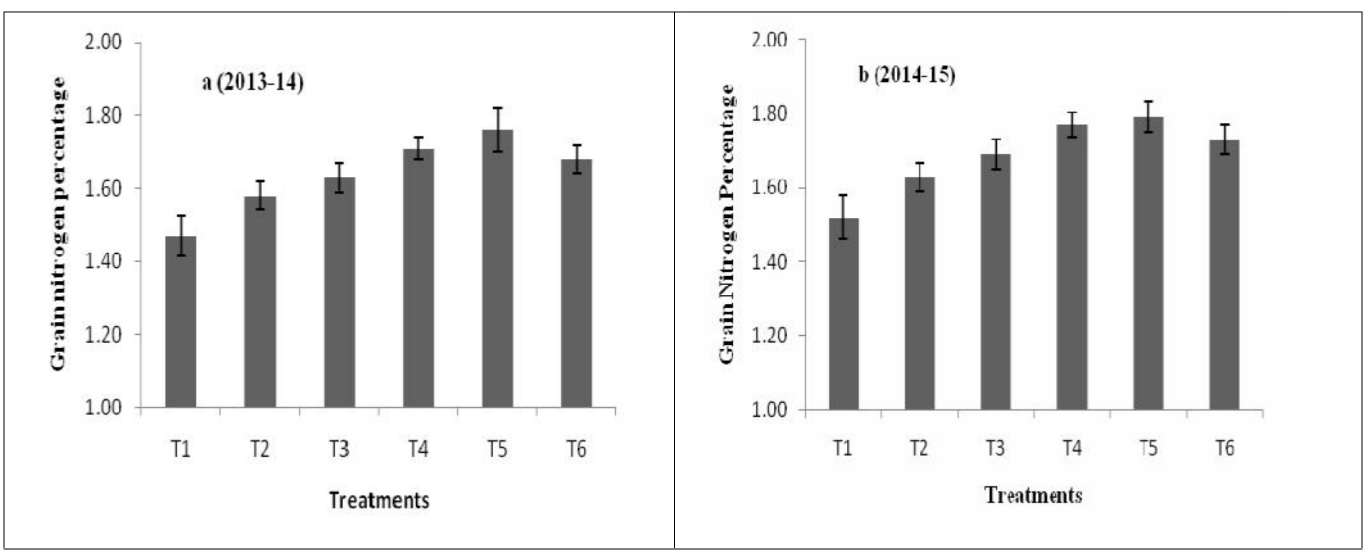


Fig 2. The effect various levels of distillery spent wash, bio-compost and NPK fertilizers on LAI, LAD and CRG during 2013-14 and 2014-15.



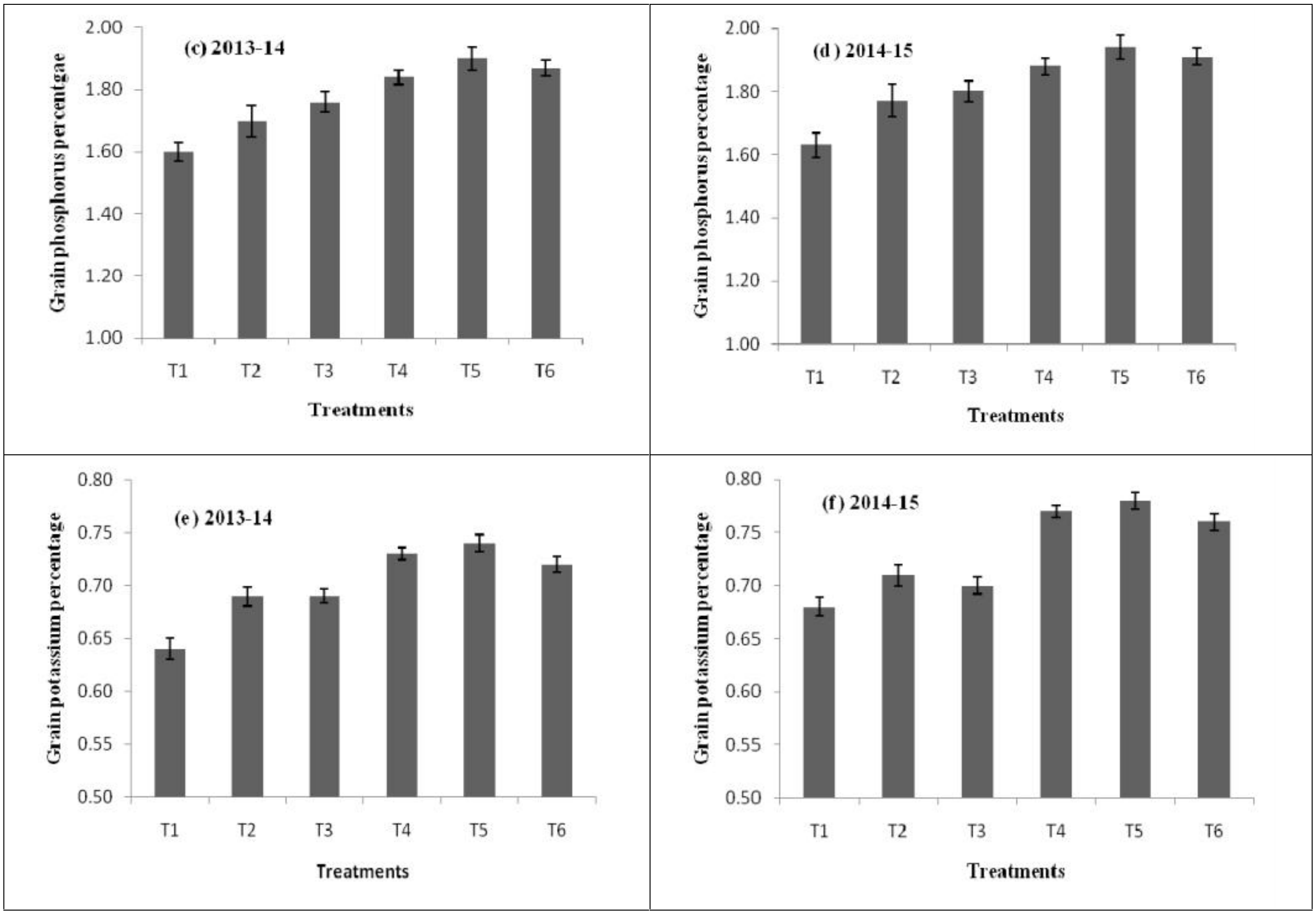
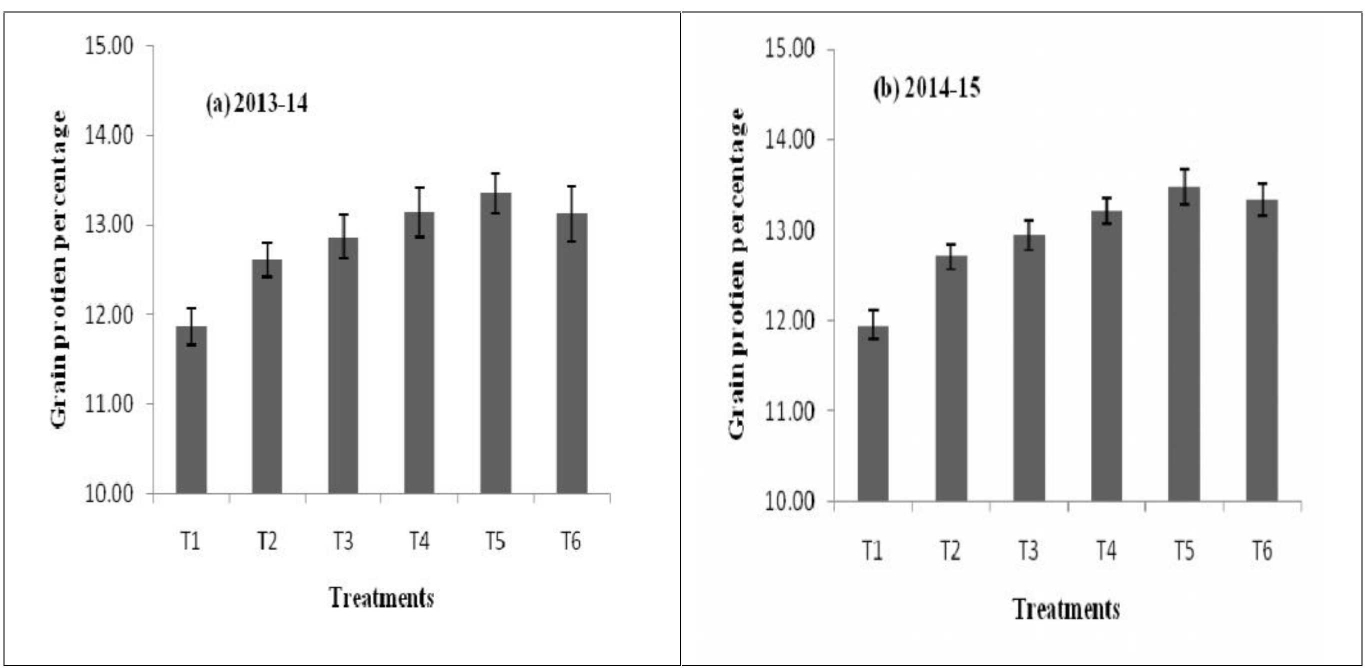


Fig 2. Influence of different combinations of distillery spent wash, bio-compost and fertilizer (NPK) on grain nitrogen (a:2013-14, b: 2014-15), grain phosphorus (c:2013-14, d: 2014-15) and grain potassium percentage (e:2013-14, f: 2014-15) of wheat crop.



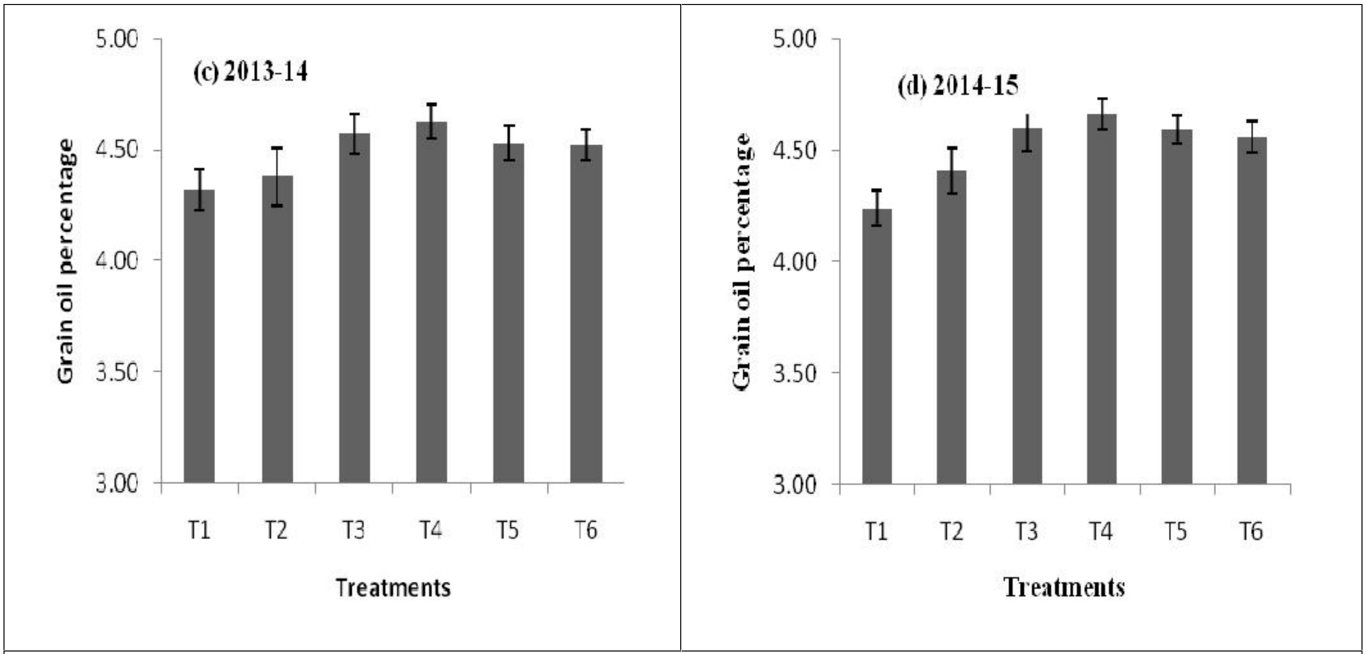


Fig 4: Influence of different combinations of distillery spent wash, bio-compost and fertilizer (NPK) on grain protein (a:2013-14, b: 2014-15) and grain oil percentage (c:2013-14, d: 2014-15) of wheat crop.

DISCUSSION

The results of present study revealed that different combinations of organic and inorganic fertilizers considerably affected growth, yield and grain quality of wheat. The application of DS, BC and various levels of NPK fertilizers remarkably improved growth attributes i.e., LAI, LAD and CGR (Fig 2). The increase in growth attributes of wheat by combined application of DS and BC might be due to the improvement in physio-chemical properties of soil and better root growth and development and that substantially increased the nutrient uptake and leading to better growth. Likewise, Sarwar *et al.* (2008) reported that application of compost of remarkably improved the soil pH, nutrient uptake and soil organic matter which led towards the substantial improvement in growth. Similarly, Suganya *et al.,* (2009) also reported that spent wash contains high amount of organic nitrogen and nutrients resulting better growth and development of the wheat crop. The various combinations of BC, DS and NPK had non-significant effect on the germination (Table 2). These results are in consistence with earlier findings (Singh and Raj, 1998) who also reported that distillery spent wash had non-significant effect on the germination.

Application of different levels of DS, BC and various levels of NPK markedly increased all yield attributes of wheat (Table 2, 3). The increase in yield and yield attributes of wheat crop by combined application of DS, BC and NPK was due to improvement in growth, soil properties, nutrient availability and uptake of nutrients. Similar findings were also observed by Ibrahim *et al.* (2008) who found that conjunctive use of inorganic fertilizers and BC remarkably improved the growth and yield of wheat. Moreover, Boateng *et al.,* (2006) and Nawaz *et al.,* (2017) found that combined application of BC and NPK substantially improved the yield and quality due to harmonizing and synergistic effects of BC and NPK fertilizers. Additionally, Jagadeeswari and Kumaraswamy, (2000) reported that conjunctive use of BC and synthetic fertilizers, remarkably improved the crop performance due to improvement, in nutrient availability and soil properties.

Similarly, the increase in yield and yield attributes of wheat crop by DS might be due to the increase in nutrient uptake, which ultimately increased the yield and yield attributes (Table 2, 3). Similar findings were also reported by Chandraju *et al.* (2008) they found a remarkable increase in crop yield by combined application of DS and synthetic fertilizers. Moreover, DS also contains appreciable amount of macro and micronutrients, thus it improved the crop growth and yield (Table 2). Our findings are supported with earlier results of Nandy *et al.* (2008), Ramana *et al.* (2000) they found that distillery spent wash and NPK fertilizers significantly improved the growth and yield of rice crop. The different combinations of DS, BC and inorganic NPK significantly improved the grain nutrient contents (Fig. 3). Similar findings were also reported by Zheljazkov and Warman (2004) and Chandraju *et al.* (2008), they reported that application of BC and DS significantly enhanced the nutrient uptake in wheat crop thus, improved the grain nutrient concentrations. In the present study application of different levels of DS, BC and various levels of NPK improved the grain protein contents, but had non-significant effects on the grain oil contents (Fig. 4). Similarly, various researchers also reported that application of sugar industry effluents remarkably improved quality and yield by improving the soil health and uptake of nutrients (Nandy *et al.,* 2008).

Conclusion: The different combinations of DS, BC and NPK levels considerably influenced the growth, yield and grain quality of wheat crop. However, the maximum improvement in growth, yield and quality were recorded with the use [(DS 25% (32 m^3) + BC 25% (225kg ha^{-1}) + F 50% (60-50-30 NPK kg ha^{-1})]. Moreover, the use of organic sources would reduce reliance on the synthetic fertilizers, with additional benefits of environmental protection.

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