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INTEGRATION OF COMPOST WITH MINERAL NPK FERTILIZERS FOR IMPROVING WHEAT YIELD AND SOIL HEALTH

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Abstract

Treating the soil with balanced and appropriate fertilizers is vital for obtaining optimum yield and maintaining soil health in a sustainable manner. One of the bottlenecks to sustainable agricultural production is soil depletion due to unbalanced fertilization. To overcome these problems, a pot experiment was carried out, to explore the potential of composts and mineral fertilizers on the soil health, yield and NPK uptake in wheat in calcareous soil. NPK were supplemented through different sources including T1: control, T2: 100% NPK as compost I (CI), T3: 100% NPK as compost II (CII), T4: 50%NPK each as CI and mineral fertilizers, T5: 50%NPK each as CII and mineral fertilizers, T6: 100% NPK as mineral fertilizers (120: 90: 60 kg ha^{-1}). Significantly taller plants of (92.6 cm), higher spike length (11.60 cm), thousand grain weight (47.54 g), biological yields (9706.2 kg ha^{-1}) and grain yield (4070 kg ha^{-2}) were recorded at T5. Similarly, maximum leaves N content (1.54%) and P content (0.19%), soil mineral N (192.8 kg ha^{-1}), nitrogen use efficiency (36.1 higher over control) and minimum soil pH (7.76) were also recorded were also observed at in pots treated with (50% NPK each as CII and mineral fertilizers) while the organic matter was highest in pots treated with full dose of CI. Therefore, application of NPK 50% each as mineral fertilizers and compost (CII) is recommended for obtaining optimum crop yield and improved soil and crop quality under calcareous soils.

Key words: Compost, Grain yield, Nitrogen use efficiency, Organic matter, Wheat.

Introduction

Sustainable agricultural practices are essential to ensure food security and minimize environmental degradation. Wheat (*Triticum aestivum* L.) is a staple food crop grown worldwide, and its productivity is critical to meeting the increasing demand for food (Rebouh *et al*., 2023). However, modern wheat cultivation relies heavily on chemical fertilizers, particularly nitrogen (N), phosphorus (P), and potassium (K) fertilizers (Mojid *et al*., 2012). Although these fertilizers promote high yields, long-term use without adequate soil management practices has led to significant challenges, including soil degradation, declining fertility, and reduced organic matter content and ultimately reduced crop productivity (Barłóg, 2023). (Shah *et al*., 2010; Adnan *et al*., 2019). The continuous dependence on chemical fertilizers poses environmental risks such as nutrient leaching, soil acidification, and greenhouse gas emissions (Yang *et al*., 2024). These issues highlight the need for integrated nutrient management (INM) practices, where both organic and inorganic fertilizers are strategically combined. Compost, a product of decomposed organic material, serves as an essential component of sustainable agriculture (Meena & Vishnuvardhan, 2021). (Pane *et al*., 2015). Application of compost has many benefits in terms of enhancing soil organic matter and soil microbial activities (Scotti *et al*., 2015). Application of composts has also been reported to supplement the artificial application of primary (NPK) and secondary (Ca, Mg) macro nutrients in soil (Donn *et al*., 2014).

The content of Soil Organic Carbon (SOC) can be increased through the application of organic inputs like animal, plants and microbial residues, peat, manure, biochar and slurry may help in enhancing soil fertility to tolerate the adverse effects of pathogens (Scotti *et al*., 2015). The use of PGPR and combination of organic amendments decreases the requirement of inorganic fertilizers (Moharana *et al*., 2018). The trend of using organic manures i.e. farm yard manure (FYM) and poultry manure is increasing for producing higher crop yield without disturbing soil health (Ali *et al*., 2017). As soil fertility is known to deplete due to continuous use of synthetic fertilizers, hence the integration of organic manure with inorganic fertilizers may improve soil fertility and productivity. This improvement may be due to the slow and gradual release of nutrients from organic manure (Timsina, 2018). When organic amendments are used, they increase soil fertility and tend to produce higher yield without causing disturbance of soil quality (Arif *et al*., 2013). Organic amendments to the soil, positively affect organic matter, soil water storage capacity, maintain cation exchange capacity, soil water infiltration, increase soil aeration, maintain soil porosity and soil biological activities (Muhammad *et al*., 2019; Agbede, 2019).

Comparatively, organic fertilizers contribute more in terms of soil fertility, soil microbial activity, soil water infiltration and soil moisture holding capacity against sole application of mineral fertilizers (Meagy *et al*., 2016). However, the nutritional profile of Pakistani soils necessitate that the farmers must apply inorganic fertilizers. Therefore, integrated use of organic and inorganic fertilizers is necessary for better nutritional supplementation on one hand and soil health on the other hand. Application of integrated fertilizers has been reported to improve the quality parameters of wheat grain (Dhaliwal *et al*., 2015). Organic inputs play a crucial role in improving soil health by enriching it with essential nutrients, increasing organic matter, enhancing water-holding capacity, and promoting beneficial microbial activity. They also contribute to carbon sequestration, reduce soil erosion, and improve soil structure over time (Bhattacharya *et al*., 2016; Iqbal *et al*., 2024). However, the effectiveness of organic inputs varies based on their type, quality, and the way they interact with specific soil conditions and crop systems, indicating a need for further research to optimize their use for sustainable agriculture (Gamage *et al*., 2023). Integrating compost with mineral NPK fertilizers offers a balanced approach to soil fertility management. It aims to optimize nutrient availability to plants while mitigating the adverse environmental impacts of excessive chemical inputs. Furthermore, this strategy contributes to long-term soil health, improves nutrient-use efficiency, and can sustain or even enhance wheat productivity. The continuous use of organic manures with chemical fertilizer such as NPK could significantly increase soil organic carbon, total amount of nitrogen and existing soil P rate (Ali *et al*., 2012; Iqbal *et al*., 2023).

The integration of compost with mineral NPK fertilizers represents a promising strategy to address the dual challenge of increasing wheat yields while preserving soil health. However, the optimal rates and timing of compost and fertilizer applications need to be carefully studied to achieve the desired results. Various factors, including soil type, climate, and wheat variety, influence the effectiveness of this integrated approach. Thus, location-specific research is crucial to developing practical recommendations for farmers. Thus keeping in view the importance of compost and its integration with inorganic fertilizers and its impact on crop growth, yield, primary macro nutrients acquisition by the crop, N use efficiency and soil properties the present study was designed to optimize the combination of compost and NPK fertilizers for optimum yield and NPK uptake in wheat under alkaline calcareous soil.

Material and Methods

Experimental site details: A pot trial was performed at agriculture research farm the University of Swabi, in Rabi 2020. The trial was laid out using completely randomized design (CRD) having five replications. Pot (1.5 feet deep x 1 feet wide) was used for wheat seed plantation. A composite soil sample was taken for the determination of soil properties from the soil heap before treatment application and filling of pots with soil. Wheat variety Pirsabak 2015 was sown with a seed rate of 100 kg ha^{-1} in each pot. To ensure use of equal seed rate, similar numbers of seeds were planted in each pot. Water requirement was met through sprinkling from sprinkler as and when required. All other agronomic practices were kept as per standard protocol of the wheat crop. The details regarding the characteristics of the soil and composts used in the excrement are given in (Table 1).

Experimental treatments details: Compost prepared from municipal organic waste was used as simple compost (Compost 1 containing 1.05% N) and enriched compost (Compost II containing 1.52%N) in the experiment with different combination of mineral fertilizers NPK. The simple compost was enriched with poultry litter (10%), Rock Phosphate (5%), Plant Growth Promoting Rhizobacteria (PGPR) (1%), and ammonium sulphate [$(NH_4)_2SO_4$] (1%). The compost also supplied P and K nutrients however, to meet 100 % P and K requirement the remaining amount was met through mineral fertilizers as SSP and SOP. Nutrients were integrated in different proportions like T1: control, T2: full dose of compost I (containing 1.05% N) @ of 12 tons ha^{-1}, T3: full dose of compost II (containing 1.52% N) @ of 8 tons ha^{-1}, T4: half dose of compost I (@ of 6 tons ha^{-1}) + 50% recommended NPK as mineral, T5: half dose of compost II (@ of 4 tons ha^{-1}) + 50% recommended NPK as mineral fertilizers, T6: 100% recommended NPK as mineral fertilizers (@ 120: 90: 60 kg ha^{-1}).

Procedure of recorded observations: The growth and yield attributes in terms of plant height, spike length and 1000-grains weight, biological yield and grain yield was determined. Plant height and spike length was measured at maturity with the help of measuring tape (Basir *et al*., 2018). The 1000-grains were counted and weighted to estimate the data of 1000-grains weight (Khan *et al*., 2023). The biological yield and grain yield were estimated from each treatment and data was represented in kg ha^{-1} (Khan *et al*., 2022). Phosphorus concentration in plant leaves was measured by the method explained by (Zhang & Kovar, 2009). Leaves nitrogen concentration was measured by Kjeldhal method (Bremner and Mulvany, 1982) through the following formula:

$$\% \text{ N} = \frac{(\text{Blank} - \text{Reading}) \text{ x } 0.005 \text{ x } 0.014 \text{ x } 100}{\text{Wt. of sample x Sample taken}} \text{ x } 100$$

To determine soil total nitrogen at pre sowing a composite soil sample was taken while at post-harvest an individual soil sample from each trial pot was taken and was brought to laboratory in plastic hand bags. The collected soil samples was dried and then grinded and was sieved. Soil total nitrogen was calculated in every pot, by the procedure (Kjeldahl) as described by (Bremner and Mulvaney, 1982) through the following formula:

$$\text{Total N } \% = \frac{(\text{ml sample} - \text{Blank}) \text{ x } 0.005 \text{ x } 0.014 \text{ x } 100}{\text{Wt. of soil (g) x v of digested sample}} \text{ x } 100$$

Soil pH was measured by the procedure as described by (McLean, 1982). Soil organic matter fraction was calculated by the method of (Nelson and Sommer 1982) using the following formula:

$$\% \text{ O. M} = \frac{(\text{Blank} - \text{Sample}) \text{ x N x } 0.69}{\text{Wt. of sample}} \text{ x } 100$$

Nitrogen use efficiency was quantified by the following formula:

$$\text{NUE (kg kg}^{-1}) = \frac{\text{GY (kg)}}{\text{N supply}}$$

GY represent grain yield, while N supply represents (N content of soil at planting and N applied from fertilizer). N supply is further elaborated as the addition of N supplied from fertilizer and total N uptake in control where no N is applied (Limon-Ortega *et al*., 2000).

Statistical analysis

The data were statistically analyzed for completely randomized design and means were compared among different treatments by using least significant differences (LSD) test ($p\leq0.05$) (Jan *et al*., 2009).

Results

Agronomic attributes: Regarding the effect of compost types and NPK mineral fertilizers on wheat plant height the data given in (Table 2) showed that the maximum plant height of wheat was recorded with treatment T5, which showed an increase of 16.04% over T1 (control). This was followed by treatments T4 and T6, with an increase of 10.78 and 8.77% respectively over T1. However no significant change was observed for plant height between T4 and T6. Similarly no significant change was also observed for plant height between treatments T2 and T3, however still an increase of 3.76 and 7.02% was observed over treatment T1. Lower plant height was observed by treatment T1. Spikes m^{-2} was distinctly influenced by the application of composts and NPK mineral fertilizers. Significantly maximum spikes were recorded with treatment T5, which showed an increase of 52.73% over T1 (control). This was followed by treatments T4 and T6, with an increase of 39.79 and 35.51% over T1. However no significant change was observed for plant height between treatments T4 and T6. Minimum spikes m^{-2} was recorded by treatment T1. This was followed by treatments T2 and T3, having an increase of 14.22 and 23.32% respectively over T1. Significantly greater 1000 grains weight was recorded with treatment T5, which showed an increase of 16.04% over T1 (control). This was followed by treatments T4 and T6 having an increase of 24.25 and 17.85% respectively over T1. Lowest 1000 grains weight was recorded with treatment T1. This was followed by treatments T2 and T3 which showed an increase of 9.28 and 13.20% respectively over T1. However no significant change was observed for 1000 grains weight between treatments T4 and T6. The grain yield of wheat increased significantly with the application of composts and NPK mineral fertilizers. The grain yield varied from 2991 and 4070 kg ha^{-1} over the treatments. Like others parameters treatment T5 produced the highest grain yield, showing 36.07% yield enhancement over control (T1). This was followed by treatments T4 and T6, showing an increase of 23.91 and 22.27% yield enhancement over T1. However no significant change was observed for grain yield between treatments T4 and T6. Lowest grain yield was recorded at treatment T1. This was followed by treatment T2 and T3 having an increase of 12 and 17.72% yield enhancement over T1. Maximum biological yield was recorded with treatment T5, showing 42.58% enhancement over T1 (control). This was followed by treatments T4 and T6, showing 24.58 and 21.14% enhancement over treatment T1. Lowest biological yield was recorded by treatment T1. This was followed by treatmentsT2 and T3, sowing an increase of 3.44 and 11.02% respectively over treatment T1.

Leaves N, P and K concentration: The N content in the wheat leaves was affected owing to combined use of composts and NPK mineral fertilizers (Table 3). Maximum leaves N content was recorded with treatment T5, showing an increase of 54% over T1 (control). This was followed by treatments T4 and T6, showing 40 and 30% enhancement over treatment T1 (control). Lowest leaves N content was recorded by treatment T1. This was followed by treatments T2 and T3, showing an increase of 10 and 18% respectively over treatment T1. However no significant change was observed for leaves N content between treatments T2 and T3. Greater leaves P content was recorded with treatment T5, having an increase of 163.9% over treatment T1 (control). This was followed by treatments T4 and T6, showing 122.2 and 83.3% enhancement over treatment T1. While lowest leaves P content was recorded at treatment T1. This was followed by treatments T2 and T3, showing 41.7 and 55.6% enhancement over treatment T1. However no significant change was observed for leaves P content between treatments T2 and T3. Maximum leaves K content was recorded with treatment T6, showing (256.0%) enhancement over T1 (control). This was followed by treatments T4 and T6, showing (110.3 and 79.3%) enhancement over T1. While lowest leaves K content was recorded at treatment T1. This was followed by treatments T2 and T3, showing (25.9 and 50.0%) enhancement over treatment T1.

Soil pH, organic matter and mineral NPK concentration: Application of composts types and NPK mineral fertilizers resulted in significant decrease in soil pH (Table 4). Specifically, highest soil pH of 7.94 was recorded with treatment T1. This was followed by treatments T6 and T5 having soil pH of 7.82 and 7.81. However no significant change was observed for soil pH content between treatments T5, T4 and T3. Lower soil pH 7.75 was observed with treatment T2. The soil organic matter content also increased with composts and NPK mineral fertilizers application. Maximum soil organic matter content was recorded with treatment T2, showing (144.2%) enhancement over T1 (control). This was followed by treatments T3, T4 and T5, showing (142.3, 107.7 and 101.9%) increase over T1. Lower soil organic matter content was observed with treatment T6. Soil mineral nitrogen (SMN) is one of the fertility indicators of soil. The application of composts types and NPK mineral fertilizers to soils can result in a significant increase in concentrations of SMN (Table 4). Maximum SMN content was recorded with treatment T5, showing (128.6%) enhancement over Treatment sT1 (control). This was followed by treatments T4 and T6, having an increase of 110.7 and 82.1% over T1. Minimum SMN content was observed with treatment T1. This was followed by treatments T2 and T3, showing an increase of 23.8 and 40.5% over T1. The addition of composts types and NPK mineral fertilizers notably increased soil phosphorus content. Maximum soil phosphorus content was recorded with treatment T5. Compared to treatment T1 (control), the corresponding increase in soil phosphorus content for treatment T5 was 215.6%. This was followed by treatments T4 and T6, showing (96.4 and 96.1%) improvement over T1. However, no significant difference was seen between these two treatments T4 and T6. Minimum soil phosphorus content was observed with treatment T1. This was followed by T2 and T3, showing (23.7 and 52.3%) improvement over T1. Soil K content is one of the major macro nutrient determines the quality of the crop. In the current study greater soil K content was recorded with treatment T5. Compared to treatment T1 (control), the corresponding increase in soil potassium content for treatment T5 was 113.6%. This was followed by treatments T4 and T6, showing (74.2 and 72.2%) improvement over T1. However, no significant difference was seen between these two treatments T4 and T6. Minimum soil potassium content was observed with treatment T1. This was followed by T2 and T3, showing (12.6 and 27.8%) improvement over T1.

Nitrogen use efficiency: The application of compost and NPK fertilizers significantly affected the Nitrogen use efficiency (NUE) as shown in table 5. In our study maximum NUE was observed with treatment T5, where half dose of CII and 50% NPK were added to the soil. Compared to treatment T1 (control), the corresponding increase in NUE for treatment T5 was (36.1%). This was followed by treatments T4 and T6, showing (23.9 and 22.3%) improvement over T1. However, no significant difference was seen between these two treatments T4 and T6. Lower NUE was observed with treatment T1. This was followed by T2 and T3, showing (12.0 and 17.7%) improvement over T1.

Table 1. Physico-chemical properties of experimental soil and composts used in the experiment.

Parameter	Unit	Soil	Compost (CI)	Enriched compost (CII)
pH	------	7.92	7.94	7.78
Electrical conductivity	dS m^{-1}	0.94	1.78	1.84
$CaCO_3$	%	15.67	-----	-----
Organic carbon	%	0.39	19.11	15.28
Nitrogen	%	0.021	1.05	1.52
Phosphorus	%	0.00037	0.66	1.42
Potassium	%	0.0074	0.72	0.94
Copper	mg kg^{-1}	-----	11.2	14.4
Zinc	mg kg^{-1}	-----	40.6	51.5
Iron	mg kg^{-1}	-----	322	574
Manganese	mg kg^{-1}	-----	51.2	66.5
C:N	-----	19	18	10
C:P	-----	-----	28.9	10.7
C:K	-----	-----	26.5	16.3

Table 2. Yield and yield components of wheat as affected by integration of compost and NPK fertilizers.

Treatments	Plant height (cm)	Spike length (cm)	1000 grain weight (g)	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})
T1: Control	79.8 d	7.92 e	36.2 e	6807.6 f	2991 f
T2: Full dose of compost I	82.8 c	8.94 d	39.56 d	7042 e	3350 e
T3: Full dose of compost II	85.4 c	9.76 c	40.98 cd	7558 d	3521 d
T4: Half dose of compost I + 50% NPK	88.4 b	10.60 b	44.98 b	8456 b	3706 b
T5: Half dose of compost II + 50% NPK	92.6 a	11.60 a	47.54 a	9706 a	4070 a
T6: 100% NPK	86.8 b	10.26 bc	42.66 c	8247 c	3659 c
LSD (α= 0.05)	2.753	0.587	1.958	198.17	92.72

Values with different lower-case alphabets in each column are statistically varying at $\alpha = 0.05$. Full and half dose of compost II correspond to 12 and 6 compost Mg ha^{-1} while, full and half dose of compost II corresponds to 8 and 4 compost Mg ha^{-1}, respectively. Furthermore, 100 and 50 % NPK represent 120: 90: 60 and 60:45: 30 kg NPK ha^{-1}, respectively

Table 3. Wheat NPK concentration as affected by integration of compost and NPK fertilizers

Treatments	Leaves N content (%)	% Increase over control	Leaves P content (%)	% Increase over control	Leaves K content (%)	% Increase over control
Control	1.0 e		0.072 e		1.16 f	
Full dose of compost I	1.1 d	10.0	0.102 d	41.7	1.46 e	25.9
Full dose of compost II	1.18 d	18.0	0.112 d	55.6	1.74 d	50.0
Half dose of compost I + 50% NPK	1.40 b	40.0	0.160 b	122.2	2.44 b	110.3
Half dose of compost II + 50% NPK	1.54 a	54.0	0.190 a	163.9	4.13 a	256.0
100% NPK	1.30 c	30.0	0.132 c	83.3	2.08 c	79.3
LSD (α= 0.05)	0.099	---	0.013	---	0.270	---

Values with different lower-case alphabets in each column are statistically varying at $\alpha = 0.05$. Full and half dose of compost II correspond to 12 and 6 compost Mg ha^{-1} while, full and half dose of compost II corresponds to 8 and 4 compost Mg ha^{-1}, respectively. Furthermore, 100 and 50 % NPK represent 120: 90: 60 and 60:45: 30 kg NPK ha^{-1}, respectively

Table 4. Post-harvest soil pH, organic matter and mineral NPK concentration as affected by integration of compost and NPK fertilizers.

Treatments	pH	Organic matter (%)	Nitrogen (mg kg^{-1})	Phosphorus (mg kg^{-1})	Potassium (mg kg^{-1})
Control	7.94 a	0.52 f	84 f	3.08 e	198 e
Full dose of compost I	7.75 de	1.27 a	104 e	3.81 d	223d
Full dose of compost II	7.76 c	1.26 b	118 d	4.69 c	253 c
Half dose of compost I + 50% NPK	7.77 cd	1.08 c	177 b	6.05 b	345 b
Half dose of compost II + 50% NPK	7.81 c	1.05 d	192 a	9.72 a	423 a
100% NPK	7.82 b	1.04 e	153 c	6.04 b	341 b
LSD (α= 0.05)	0.031	0.05	4.88	0.396	24.75

Values with different lower-case alphabets in each column are statistically varying at $\alpha = 0.05$. Full and half dose of compost II correspond to 12 and 6 compost Mg ha^{-1} while, full and half dose of compost II corresponds to 8 and 4 compost Mg ha^{-1}, respectively. Furthermore, 100 and 50 % NPK represent 120: 90: 60 and 60:45: 30 kg NPK ha^{-1}, respectively

Table 5. Nitrogen use efficiency (kg kg^{-1}) as affected by integration of compost and NPK fertilizers.

Treatments	NUE	% Increase over control
Control	24.93 e	---
Full dose of compost I	27.92 d	12.0
Full dose of compost II	29.34 c	17.7
Half dose of compost I + 50% NPK	30.88 b	23.9
Half dose of compost II + 50% NPK	33.92 a	36.1
100% NPK	30.48 b	22.3
LSD (α= 0.05)	2.45	---

Values with different lower-case alphabets in each column are statistically varying at $\alpha = 0.05$. Full and half dose of compost II correspond to 12 and 6 compost Mg ha^{-1} while, full and half dose of compost II corresponds to 8 and 4 compost Mg ha^{-1}, respectively. Furthermore, 100 and 50 % NPK represent 120: 90: 60 and 60:45: 30 kg NPK ha^{-1}, respectively

Correlation analysis: The correlation analysis (Table 6) indicated that all the tested traits including plant height, spike length, 1000 grain weight, grain and biological yield, leaves NPK continents, grain and soil mineral nitrogen, extractable P and K and soil organic matter were positively corelated with each other while soil pH was negatively corelated with all the attributes as shown in Fig. 1a, b, c, d, e & f. Generally, the coefficient of co-relation (r) values ranged from 0.517 to 0.911 for positively corelated attributes and -0.438 to -0.904 for the pH with other testes attributes. Soil organic matter (r = 0.90) and extractable N (r = 0.90), P (r = 0.57) K (r = 0.0.85) were all significantly and negatively correlated with soil pH.

Discussion

The application of both composts and mineral fertilizers significantly increased plant height of wheat. Maximum plant height (cm) was observed with treatment T5 (50% compost + 50% NPK). One of the reasons of influencing the plant height by enriched compost applied as an organic source of nutrient is the slow release of nutrients that may have support the crop growth throughout growth season. Similar result were also reported by (Anwar *et al*., 2015). (Akhtar *et al*., 2009) also reported that enriched composts supplemented by chemical fertilizers had significantly affected plant height. We observed maximum spike length of wheat at treatment T5 (50% compost+50% NPK). It is because of the adequate availability of moisture and nutrient in the integrated amended plots with enriched compost and synthetic fertilizers had increased spike length. Similar results were also obtained by (Khan *et al*., 2018 and Hussain *et al*., 2018). Iqbal *et al*., (2021) stated that integrated use of enriched compost and inorganic fertilizers is better than the sole use organic manure or inorganic chemical fertilizers in terms improved soil heal, crop growth and yield. Application of 50% enriched compost and 50% NPK resulted into heavier thousand grain weight. This was probably due to the integration of nutrients which ensured sustained nutrient availability that enhanced photosynthetic rate that also enhanced the transportation of photo assimilates from the vegetative parts i.e. leaves and other green parts (refer as a source) to reproductive parts i.e. grains (refers as a sinks). This improvement of translocation of assimilates resulted into greater grain size and weight. Similar results were also obtained by (Zahoor, 2014) who stated that the sustained availability of nutrients especially readily available nitrogen from the enriched compost applied along with mineral nutrients may have increase the utilization of N through efficient photosynthetic process that led to greater grain size and weight. (Shah *et al*., 2015) also reported an increase in grain weight of wheat crop through integration of compost and synthetic nutrients. This integration of nutrients ensured the availability of required amount of nutrients in proper quantity throughout the growth season. In our experiment improved wheat grains yield was observed with treatment T5 (50% enriched compost + 50% NPK). Because the addition of 50% NPK has met the immediate nutrient requirement of crop while the application of 50% enriched compost has ensured the nutrient availability on sustainable basis through slow release during the entire growing season of wheat. (Rashid *et al*., 2014) further confirmed that provision of nutrients in a sustainable manner from enriched compost ensured nutrient availability at all growth stages that had led to efficient performance of crop in terms of yield and growth attributes of wheat crop. (Subhan *et al*., 2017) also stated that amendments of manure into the soil irrespective of its kind along with amalgamation of mineral nutrients had ensured crop productivity and soil substantially.

In our experiment maximum nitrogen concentration in leaves was observed for T5 (50% compost + 50% NPK). Because the availability of nutrients and soil biotic activity were enhanced through addition of enriched compost and mineral fertilizers that resultantly enhance crop growth and yield through maximum nutrient uptake. Our results are in conformity with those of (Shah *et al*., 2015) who determined that amendment of soil with both type nutrients i.e. organic and inorganic had increased the N uptake than one kind of fertilizer addition. One of the prominent feature of adding organic source especially compost enhances soil nutrients and improves biological properties that may influence N availability to plants (Khan *et al*., 2017). In our experiment maximum P uptake by wheat crop was observed for T5 (50% compost + 50% NPK). Because the application of both sources of nutrients i.e. organic and inorganic had significantly influenced moisture content, leaf area, plant growth and development of wheat, thus improved P and N uptake of plant. Our findings are in conformity with the findings of (Kumar *et al*., 2012) who noted significantly greater N and P uptake by wheat crop where soil amended with both types of fertilizers. The findings of (Ghosh *et al*., 2014) and (Shah *et al*., 2015) also support our findings in which they had noted a statistically greater P uptake by plants in the treatments where soil amended with both sources of macro nutrients.

In the present study total soil N content had significantly enhanced by integration of enriched compost and mineral NPK to the soil. It has been confirmed by many studies (Sheoran *et al*., 2015and Majumdar *et al*., 2007) that N content of the soil linearly increased with increasing N fertilization of the soil. Similarly soil total N concentrations were increased through soil amendment with enriched compost and NPK fertilizers (Majumdar *et al*., 2007). (Ali *et al*., 2008) is of the opinion that mineral NPK has a great relevancy with organic manure in enhancing the capability of the soil to buildup soil total N and enhance its uptake by plants. The application of organic and chemical fertilizers led to a significant change in the soil reaction. Addition of compost lowered soil pH due to its acidifying effect by producing and subsequently releasing different organic acids during the process of mineralization. These findings were in conformity with the results reported by (Datt *et al*., 2008). Moreover, Sharma *et al*., (2014) also concluded that soil pH can be moderated through organic manure application. Due to buffering capacity of humic substances in the manure, there was less variation in pH between the treatments those received enriched compost. In this experiment soil organic matter content was significantly improved by the integration of enriched compost and mineral NPK fertilization. The reason for this greater amount of organic matter is the addition of compost into the soil that enhanced soil organic matter and soil organic carbon as well. Other studies have also confirmed these results (Sharif *et al*., 2014) whose were of the opinion that addition of manure or any other organic matter content and inorganic fertilizers may improve soil organic carbon. However, some of the scientists reported that use of compost and other organic residue have linearly increased soil organic matter (Khan *et al*., 2017).

Table 6. Correlation between the tested attributes as affected by applied treatments.

	Spike length	1000 grain weight	Grain yield	Biological yield	Leaves N	Leaves P	Leaves K	Grain N	Mineral N	Extractable P	Extractable K	Soil PH	Soil OM
Plant height	0.778	0.778	0.755	0.799	0.517	0.715	0.690	0.715	0.653	0.743	0.704	-0.615	0.701
spike length		0.928	0.886	0.891	0.648	0.793	0.837	0.795	0.703	0.861	0.801	-0.714	0.760
1000 grain weight		0.905	0.879	0.680	0.821	0.830	0.835	0.746	0.859	0.837	-0.753	0.798	
Grain yield				0.907	0.774	0.872	0.821	0.892	0.782	0.914	0.896	-0.741	0.854
biological yield				0.792	0.863	0.911	0.835	0.610	0.979	0.770	-0.617	0.712	
Leaves N						0.700	0.684	0.756	0.517	0.835	0.688	-0.438	0.593
Leaves P							0.782	0.810	0.730	0.872	0.855	-0.687	0.810
Leaves K								0.724	0.451	0.882	0.609	-0.490	0.559
Grain N									0.800	0.826	0.886	-0.738	0.855
Mineral N										0.605	0.953	-0.902	0.982
Extractable P											0.784	-0.574	0.707
Extractable K												-0.853	0.973
Soil PH													-0.904

N, P and K represents nitrogen, phosphorus and potassium respectively

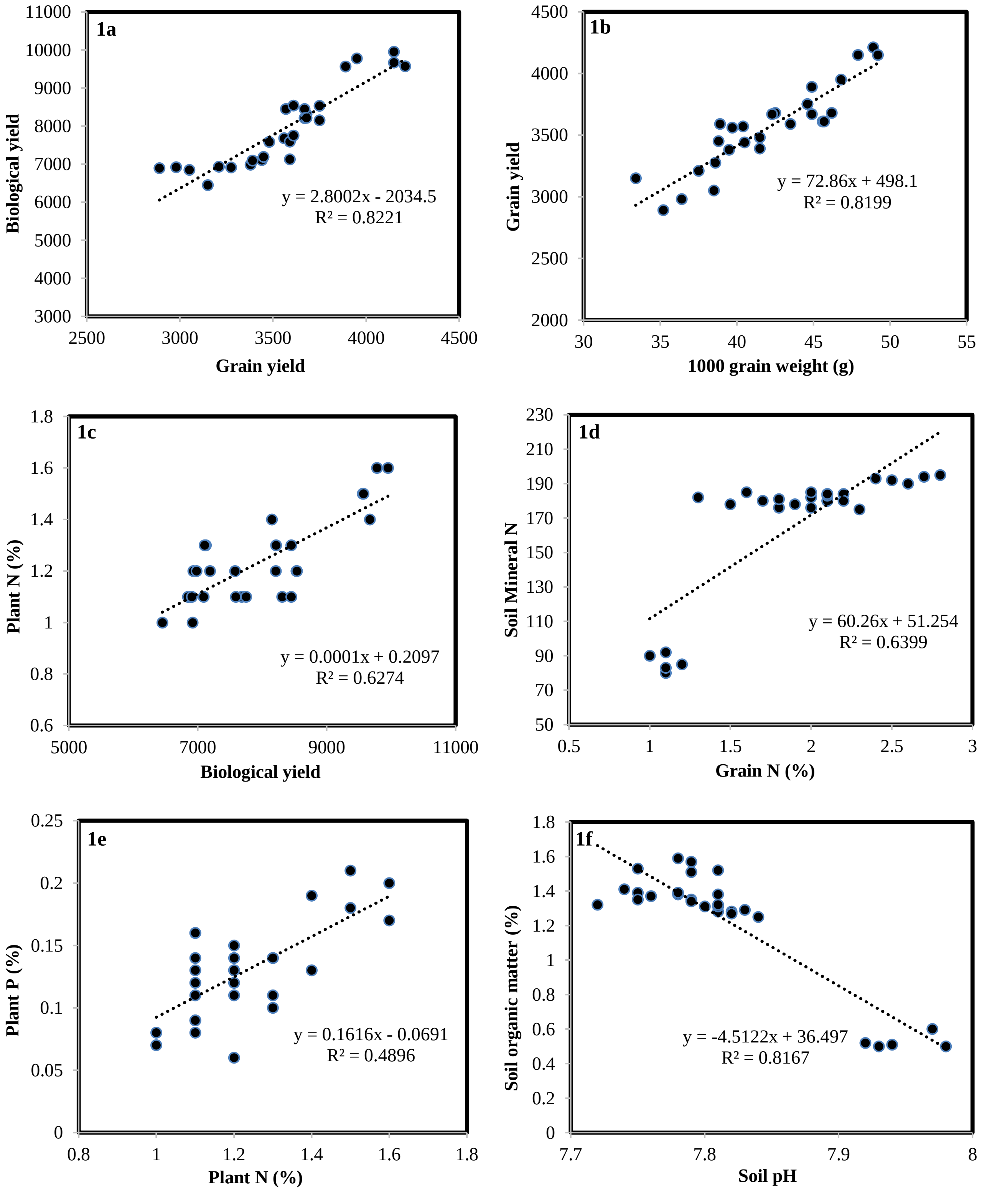

Fig. 1. Relationship between biological and grain yield (a), grain yield and 1000 grain weight (b), plant N concentration and biological yield (c), soil and grain nitrogen (d), plant N and P (e) and soil organic matter and pH (f).

Conclusion

The application of NPK via half each as composts and mineral NPK fertilizers (50% compost-II + 50% NPK) significantly improved post-harvest soil physico-chemical properties, quality, yield and yield components of wheat. The higher NUE (36.1 % increase over control) was also observed for pots treated with NPK as 50% each from CII and mineral fertilizers. All the tested traits were positively corelated with each other except for pH. Hence it can be concluded that the combined application of composts and mineral fertilizers (50% compost-II + 50% NPK) is a promising option for improving wheat yield, crop quality and post-harvest soil physico-chemical properties in semi-arid climatic conditions under calcareous soils.

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