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Assessing The Effectiveness of Farmyard Manure, Poultry Manure And Nitrogen Application For Wheat Productivity Under Various Tillage Systems

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ABSTRACT

Wheat is a staple food globally and is greatly affected by nutrient management practices usually required for fixing soil organic carbon and optimum growth of the crop. Therefore, to determine the effectiveness of amendments of organo-mineral and tillage systems on phenology, growth of wheat, and yield and yield components, a field experiment was conducted at the Agronomic Research Area, University of Agriculture Faisalabad. The experiment was triplicated to minimize the error percentage under a randomized complete block design (RCBD) with a split-plot arrangement. There were two tillage practices such as reduced tillage and conventional tillage which were randomized in main plots and six nutrient management practices as Control, required levels of N from NPK, farmyard manure (FYM), poultry manure (PM), half of N from NPK + half of N from FYM, and half of N from NPK + half of N from PM respectively. These treatments were randomized in subplots. Data on growth, yield, and phenology was recorded during the experiment according to standard procedure. Results revealed that wheat crops reached earlier phenological stage i.e., tillering, anthesis, and maturity under the application of conventional as well as reduced tillage along with poultry manure (PM) while reducing tillage along with control (no fertilizer) has shown delay in phenological attributes. Yield and yield parameters showed highly significant variations. The application of reducing tillage along with nutrient management practices performed better in terms of yield attributes such as the number of grains per spike, grain yield, and biological yield. Whereas conventional tillage showed poor results regarding yield-related attributes. Application of reduced tillage along with the farmyard manure performed better regarding growth parameters i.e., leaf area index, leaf area duration, crop growth rate, net assimilation rate, and total dry matter, while conventional tillage along with control (no fertilizer) recorded poor results. For statistical analysis, Fisher's method of analysis of variance was

used and assessed on a 5% probability level. The treatment means were compared using Tukey's test of HSD.

Keywords: Organo-mineral, Soil Fertility, Soil productivity, Net assimilation rate, Greenhouse gases emission, Reduced tillage

Introduction

Providing the enhancing population demands higher consideration for maximum and accurate use of input resources like pesticides and fertilizers. Wheat crop is at top position among cereals to fulfilthe food demand (Ibrahim et al., 2007; Ghafoor et al., 2021). Wheat need will mayrise up to 840 million tons from its existing yield rateduring the mid-term (2050) (Sharma et al. 2015). The yield isreduced because of different factors like temperature stress, drought stress, poor-quality seeds, insect pests, and climate change, but use of synthetic fertilizers is considered more unique for wheat yield for under climate change conditions (Hochman andHoran 2018; Ghafoor et al., 2022).But only use of synthetic fertilizers reduce soil productivity that resulted in lower yield production of crops. Synthetic fertilizers play important role to enhance soil fertility and wheat yield but due to higher temperature and lower soil organic matter it costs more than combine application of farmyard manure, poultry manure and biochar. Iqbal et al. (2012) and Su et al. (2006) indicated that applying chemical fertilizers such as Nitrogen, NP, as well as NPK independently had a substantial influence upon soil organic carbon concentration. While the use of mineral nutrients in conjunction with agricultural manure resulted in a large enhance in the amount of soil properties (Dheri et al., 2021). Additionally, the mean soil organic carbon's value was lowered to about 18% in contrast to the baseline value (Su et al., 2006).

In the next few years, the utilization of natural fertilizers to fulfill the nutrients needs of crops will be an inevitable approach to enhance sustainable agriculture practices. Our soils are now confronted with a number of issues, including degraded soil health, decreased soil fertility, as well as a continually diminishing amount of organic matter of soil (Farhadet al., 2009; Jat et al., 2015; Laik et al., 2021). Organic matters loss has a detrimental effect on the physical qualities of soilwith plant development, such as loading up void spaces and eventually enhancing bulk density. Thus, Organic materials loss results in soil degradation as well as degrades soil fertility. Damages may be minimized by incorporating agricultural leftovers as well as animal's waste into the land, which reuses the far more malleable carbon back into the land and so raises the soil productivity as wellas soil quality. (Benbiet al., 2007; Swarupet al., 1998). Just because the chemical, physiological and biological possessions of the soil are usually improved by adding organic fertilizers (Maheswarappaet al., 1999).Organic additives may be used in place of mineral fertilizers during crop cultivation. Organic fertilizers are important since they are environmentally benign and have beneficial long-term benefits on nutrition as well as soil production (Elfstrandet al., 2007). It is rich in macronutrients like N, P, as well as K. Remarkably, it also is a great source of several micronutrients about which we know nothing. The second characteristic of manure is its contribution to the soil's structure. Other than providing all of these critical naturally occurring compounds and minerals, excellently decomposed manure produces substantial compost, which helps retain wetness as well as promotes smoother as well as stronger root development. Additionally, soil fertility may be increased by the use of organic matter in conjunction with fertilizers (Azad and Yousaf, 1982). In compared to chemical fertilizers, using manures also as medium of bioactive matter enhances aeration of soil, structure of soil, nutrient as well as water retention capacity, hydraulic properties, as well as bulk density (Deksissaet al., 2008; Edmeades, 2003). Applying organic additives to soil lowers soil water loss, improves water retention, as well as strengthens plants' ability to withstand drought conditions (Cheng et al., 1998). Like organic amendments in the conventional systems, reduced tillage systems also provide a potential to enhance nitrogen (N) sequestration to adapt and mitigate the greenhouse gases emissions (GHG,s) under changing climatic scenarios (Nathet al., 2017; Githongo et al., 2021). So, use of different combine strategies results in mitigating GHG's in soil and maximizing the yield level of wheat crop. Conventional tillage system can cause the manipulation of the soil physical condition, loss of related plant nutrients as compared to reduced tillage practices (Jain et al., 2014; Kumar et al., 2022). Several studies indicate that frequently using of soil cultivation results in decreasing the soil organic matter (SOM), releasing more CO_2 in atmosphere and ultimately reduces the total C content from soil (La Scala et al., 2008). Further, soil behavior may be regulated on an average basis using fertility management practices such as the use of chemical as well as organic fertilizers, rotation of crop, and tillage techniques. as well as additional layers of tiers of cropping system (Swarup, 1998 and Purakayasthaet al., 2008). The primary focus must be on the soil organic carbon pools as properties with the type of soil, fertilizers management strategies, as well as field usage (Lai et al., 1998).

Afew researches availableabout the impacts of combine effects of tillage, nutrients and organic amendments on wheat crop.So, it is the need of great importance to optimize nutrient management practices and tillage systems with best agro-management practices. Hence, the main objectives of current research included to assessing the effect of treatments on phenology and growth of wheat, and assessing the effect of treatments on yield and radiation use efficiency wheat under semiarid environmental conditions.

Material and methods

Experimental area and design

Current research was conducted at Agronomic Research Farm, University of Agriculture Faisalabad (31°45'N,73°13' E) during 2020,21. Annual rainfall 250 to 500 mm was recorded.The Randomized Complete Block Design (RCBD) with split plot arrangement by taking three replications. The gross plot size and row to row distance were 4 m × 1.8 m and 22.5 cm respectively. Seed of Akbar-2019 variety was taken from Ayub Agricultural Research Institute, Faisalabad. Treatments included i) reduced tillage and ii) conventional tillage were placed in main plots, and nutrient management practices i) control (No Fertilizer), ii) Required N from recommended NPK, iii) Farmyard Manure (FYM), iv) Poultry Manure (PM), v) Half of N from recommended NPK + Half of N from FYM and vi) Half of N from recommended NPK + Half of N from PM were placed in subplots. All other agronomic practices kept same in all plots.

Phenology parameters

Phenological characteristics included days to tillering, days toanthesis and days to maturity during crop period.

Leaf area index

The ratio of leaf area to land area is called as leaf area index, and it was calculated by using following formula suggested by (Hunt, 1978).

$$LAI = \frac{leaf\ area}{ground\ area}$$

Leaf area duration (days)

Leaf area duration was evaluated with following equation of Hunt (1978). Where LAI_1 and LAI_2

are the leaf area indices taken at time t1 and t2, respectively.

$$LAD = \frac{(LAI1 + LAI2)\ (t2-t1)}{2}$$

Crop growth rate ($gm^{-2}day^{-1}$)

Crop growth rate (CGR) was accounted as advocated by (Hunt, 1978) at each sampling date.t The total dry weights (W1 and W2) that were taken at times (t1 and t2)respectively. Then minus dry weight 1 (W1) from dry weight 2 (W2) and divide by time interval. Mean CGR was determined by averaging all CGRS computed at every one critical yield.

Net assimilation rate ($gm^{-2}day^{-1}$)

The mean net assimilation rate (NAR) was enumerated by using application of Hunt equation (1978).

$$NAR = \frac{TDM}{LAD}$$

Estimation of yield and yield components

The number of grains per spike was calculated from the selected spikes that was utilized for counting and average value was also taken for further analysis.By using the counting machine, the thousand grains were counted then weight was recorded of the counted grains with the help of digital balance. The final yield and biomass were determined from the whole units separately on the dry biomass basis and weight were recorded with the help of balance.

Statistical Analysis

Fisher's analysis of variance technique was applied to analyze the collected data statistically and means of treatments were compared by Tukey's HSD at 5% probability level (Steel, 1997).

Results

Wheat phenology and development

Tillering stage has shown the highly significant variations in response to tillage practices and nutrient management practices (Figure 1). Likewise, interactive effect of tillage practices and nutrient management practices was found significant. The earliest tillering stage (30 DAS each) of wheat was appeared under the application of conventional as well as reduced tillage along with poultry manure (PM), while reduce tillage along with control (no fertilizer) has shown the late tillering (37 DAS). Application of conventional tillage along with control (no fertilizer), farmyard manure (FYM), poultry manure (PM) and half of N from recommended NPK + half of N from PM has shown the tillering appearance as 34.00, 31.00, 33.00, and 32.00 DAS respectively.The interactive effect of tillage practices and nutrient management practices was found significant for anthesis stage of wheat crop. The earliest anthesis stage (101 DAS each) of wheat was appeared under the application of conventional as well as reduced tillage along with poultry manure (PM), while reduce tillage along with control (no fertilizer) has shown the late anthesis (108 DAS) (Figure 2). Further application of conventional tillage along with control (no fertilizer), required N from recommended NPK and half of N from recommended NPK + half of N from PM has shown the anthesis appearance as 105.00, 104.00 and 103.00 DAS respectively.Maturity stage has also shown the highly significant variations in response to tillage practices and nutrient management practices, and their interactive effects were also found significant. The earliest maturity stage (144 DAS each) of wheat was appeared under the application of conventional as well as reduced tillage along with poultry manure

(PM), while reduce tillage along with control (no fertilizer) has shown the late anthesis (150 DAS). Whereas application of conventional tillage along with control (no fertilizer), required N from recommended NPK, farmyard manure (FYM), poultry manure (PM), Half of N from recommended NPK + half of N from FYM, half of N from recommended NPK + half of N from PM has shown the maturity appearance as 148.00, 147.00, 145.00, 144.00, 146.00, and 146.00 DAS respectively (Figure 3).Leaf area index (LAI) has shown the highly significant variations in response to tillage practices and nutrient management practices. Highest leaf area index (1592.00) was recorded under the application of reduced tillage along with the farmyard manure, while conventional tillage along with control (no fertilizer) recorded the lowest leaf area index (1078.007) (Table 1). Similarly, leaf area duration (LAD) has shown the highly significant variations in response to tillage practices and nutrient management practices. Highest leaf area duration (407.00) was recorded under the application of reduced tillage along with the farmyard manure, while conventional tillage along with control (no fertilizer) recorded the lowest lead area duration (1078.007). Application of reduce tillage along with poultry manure (PM), Half of N from recommended NPK + half of N from FYM, half of N from recommended NPK + half of N from PM has shown the leaf area duration as371.97, 304.97, and 274.67 respectively and shown in (Table 2). Further, crop growth rate (CGR) has shown the highly significant variations in response to tillage practices and nutrient management practices. Highest crop growth rate (14.83) was recorded under the application of reduced tillage along with the farmyard manure, while conventional tillage along with control (no fertilizer) recorded the lowest lead area duration (9.94) (Table 3). Furthermore, net assimilation rate (NAR) has shown the highly significant variations in response to tillage practices and nutrient management practices. Highest net assimilation rate (5.41) was recorded under the application of conventional tillage along with the control (no fertilizer), while reduce tillage along with farmyard manure recorded the lowest lead area duration (3.90) (Table 4).

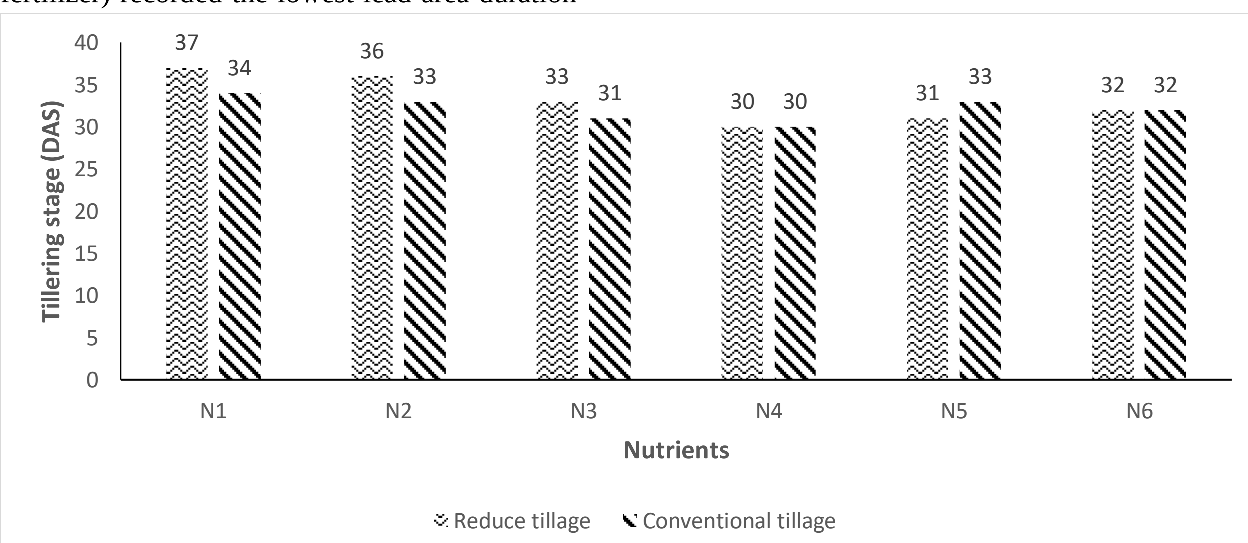

Figure 1 Interactive effect of tillage practices and nutrient management practices on tillering stage

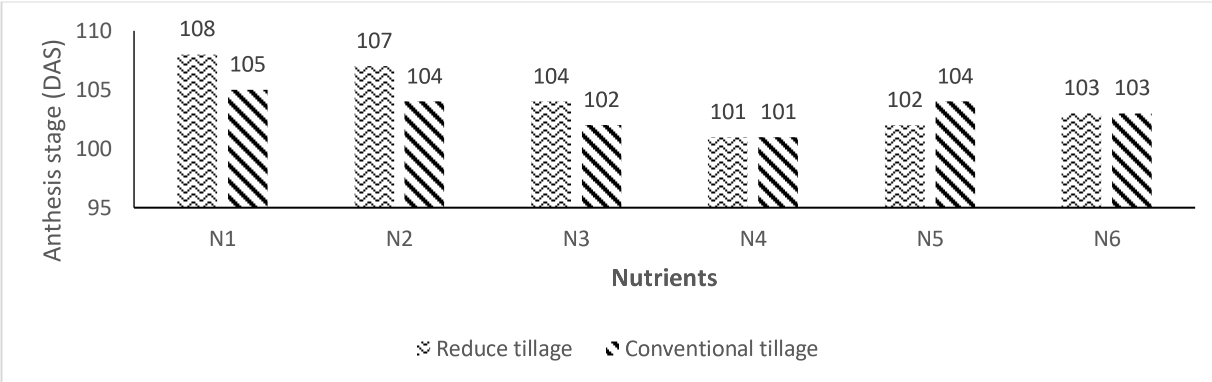

Figure 2 Interactive effect of tillage practices and nutrient management practices on anthesis stage

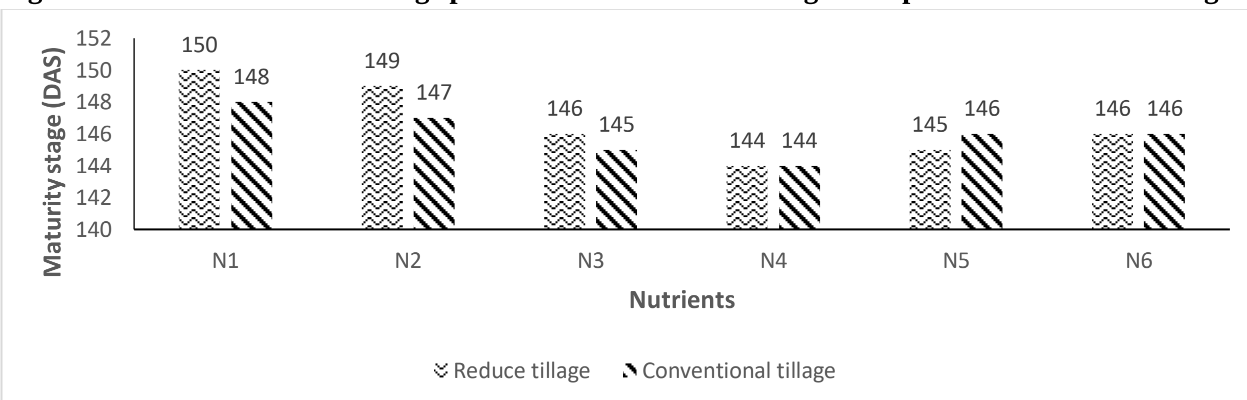

Figure 3 Interactive effect of tillage practices and nutrient management practices on maturity stage

Table 1Mean comparison of tillage practices and nutrient management practices on leaf area index

Treatments	N_1	N_2	N_3	N_4	N_5	N_6	Mean
Reduce tillage	237.71 (hi)	338.34 (bcd)	407.62 (a)	371.97 (ab)	304.97 (def)	274.67 (fgh)	322.54 (A)
Conventional tillage	198.89 (j)	300.81 (efg)	367.05 (bc)	331.28 (cde)	269.45 (ghi)	233.82 (ij)	283.55 (B)
Mean	218.3 (F)	319.57 (C)	387.33 (A)	351.62 (B)	287.21 (D)	254.24 (E)	
HSDp=0.05 Tillage practices=0.12 Nutrient practices=0.31 Interactive effect TP*NP=0.52							

Table 2Mean comparison of tillage practices and nutrient management practices on leaf area duration

Tillage practices	N1	N2	N3	N4	N5	N6	Mean

Reduce tillage	237.71 (f)	338.34 (c)	407.62 (a)	371.97 (b)	304.97 (d)	274.6 (e)	322.53 (A)
Conventional tillage	198.89 (g)	300.81 (d)	367.05 (b)	331.28 (c)	269.45 (e)	233.82 (f)	283.55 (B)
Mean	218.3 (F)	319.575 (C)	387.33 (A)	351.62 (B)	318.12 (D)	254.21 (E)	
HSDp=0.05 Tillage practices=3.71 Nutrient practices=9.67 Interactive effect TP*NP=15.9							

Table 3Mean comparison of tillage practices and nutrient management practices on crop growth rate

Tillage practices	N1	N2	N3	N4	N5	N6	Mean
Reduce tillage	10.57 (ef)	13.47 (bc)	14.83 (a)	14.11 (ab)	12.53 (cd)	11.75 (de)	12.87 (A)
Conventional tillage	9.94 (f)	12.45 (cd)	14.00 (ab)	13.28 (bc)	11.70 (de)	10.92 (ef)	12.04 (B)
Mean	10.25 (F)	12.96 (C)	14.41 (A)	13.69 (B)	12.11 (D)	11.33 (E)	
HSDp=0.05 Tillage practices=0.21 Nutrient practices=0.71 Interactive effect TP*NP=1.18							

Table 4Mean comparison of tillage practices and nutrient management practices on net assimilation rate

Tillage practices	N1	N2	N3	N4	N5	N6	Mean
Reduce tillage	4.90 (bc)	4.29 (c-f)	3.90 (g)	4.09 (fg)	4.41 (c-f)	4.61 (b-e)	4.36 (B)
Conventional tillage	5.41 (a)	4.48 (c-f)	4.13 (efg)	4.32 (d-g)	4.70 (bcd)	5.01 (ab)	4.67 (A)
Mean	5.15 (A)	4.38 (BC)	4.01 (E)	4.20 (DE)	4.55 (AB)	4.81 (B)	
HSDp=0.05 Tillage practices=0.11 Nutrient practices=0.30 Interactive effect TP*NP=0.50							

Yield and yield components

Number of grains per spike has shown the highly significant variations in response to tillage practices and nutrient management practices (Figure 4). Likewise, interactive effect of tillage practices and nutrient management practices was found significant. Highest number of grains per spike (54.6) was recorded under the application of conventional tillage along with the required N from recommended NPK, while reduce tillage along with the Half of N from recommended NPK + half of N from FYM has shown the lowest number of grains per spike (51.33). Similarly, thousand grain weight and interactive effects of tillage and N management practices have shown the highly significant variations in response.Highest grain weight (42.34 g) was recorded under the application of reduce tillage along with control (no fertilizer), while reduce tillage along with half of N from recommended NPKhas shown the lowest thousand grain weight (36.01 g) (Figure 5). Further, grain yield has shown the highly significant variations in response to tillage practices and nutrient management practices (Figure 6). Highest grain yield (16.41 g) was recorded under the application of conventional tillage along with the no fertilizer rate (control), while conventional tillage along with the poultry manure (PM) has shown the lowest grain yield (3.17 g). Application of conventional tillage along with control (no fertilizer), required N from recommended NPK, farmyard manure (FYM), poultry manure (PM), Half of N from recommended NPK + half of N from FYM, half of N from recommended NPK + half of N from PM has shown the grain yield as 4.61, 3.86, 4.05, 3.17, 4.03, and 3.77 g respectively. Furthermore, biological yield has shown the highly significant variations in response to tillage practices and nutrient management practices. Highest biological yield (16.41 g) was recorded under the application of reduce tillage along with the no fertilizer rate (control), while reduce tillage along with the half of N from recommended NPK + half of N from FYM has shown the lowest biological yield (13.44 g) (Figure 7). Application of conventional tillage along with control (no fertilizer), required N from recommended NPK, farmyard manure (FYM), poultry manure (PM), Half of N from recommended NPK + half of N from FYM, half of N from recommended NPK + half of N from PM has shown the biological yield as 115.28, 14, 16.32, 13.62, 15.31, and 13.57 g respectively.

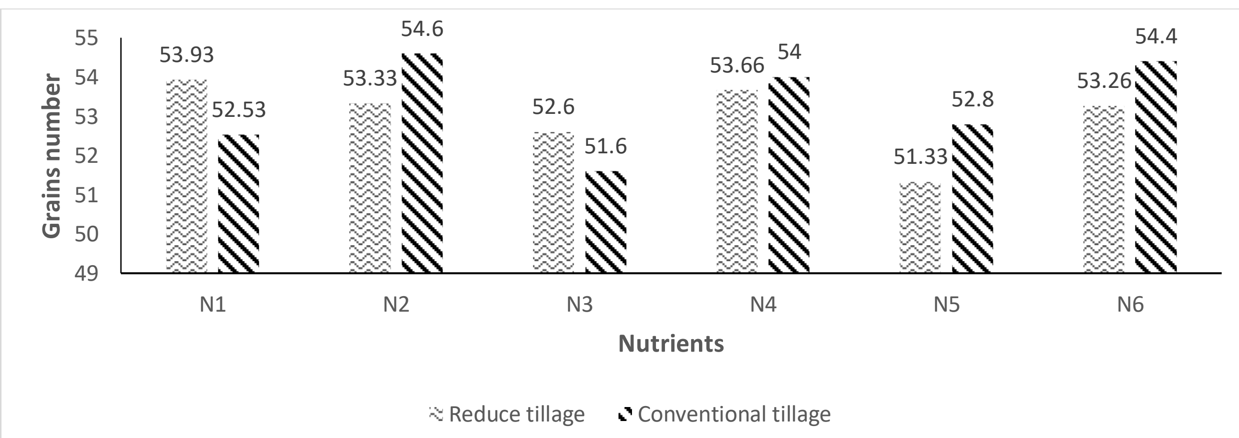

Figure 4 interactive effect of tillage practices and nutrient management practices on number of grains per spike

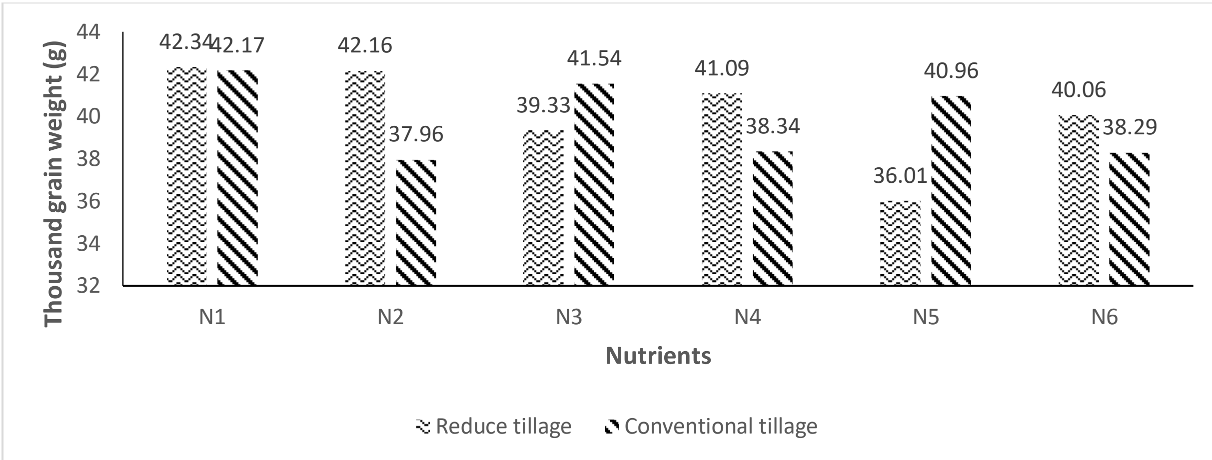

Figure 5 interactive effect of tillage practices and nutrient management practices on thousand grain weight

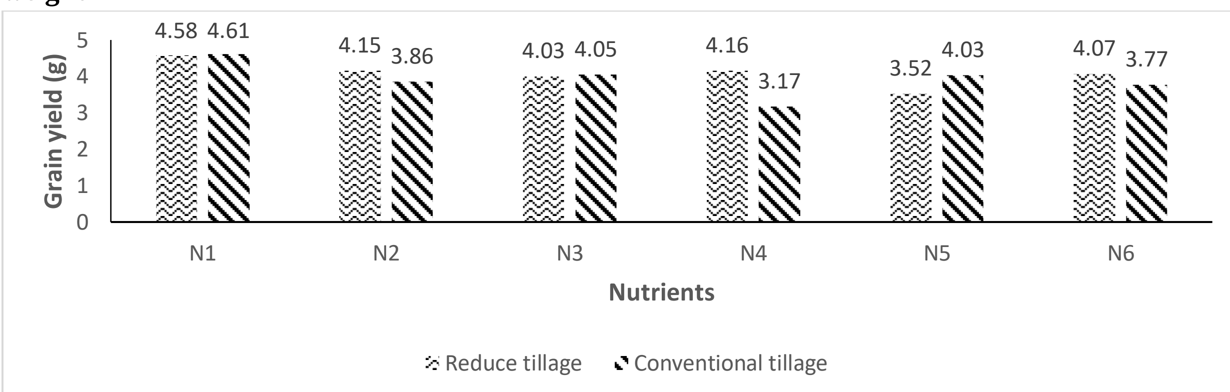

Figure 6 interactive effect of tillage practices and nutrient management practices on grain yield

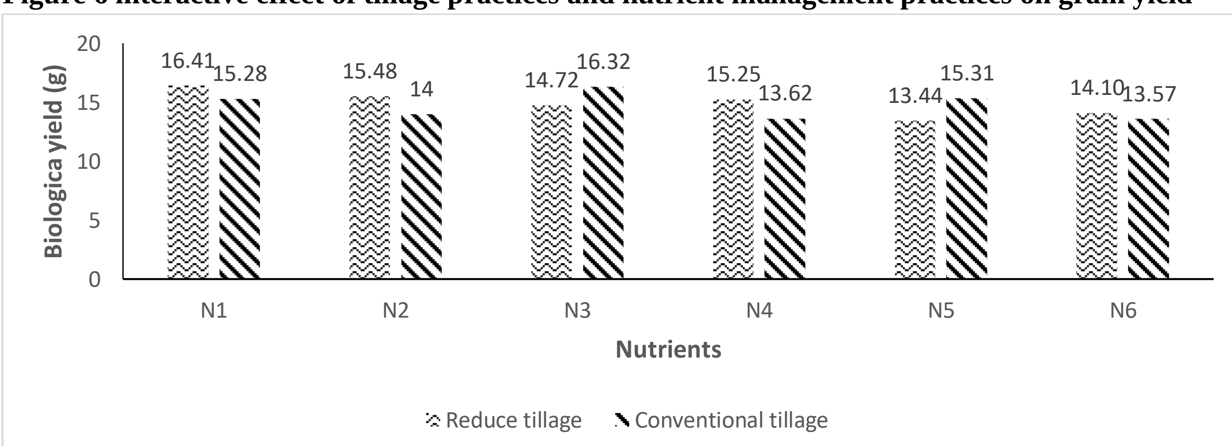

Figure 7 interactive effect of tillage practices and nutrient management practices on biological yield

Discussion

The utilization of natural fertilizers to fulfill the nutrients needs of crop will be an inevitable approach to enhance sustainable agriculture practices. Just because the chemical, physiological and biological possessions of the soil are usually improved by adding organic fertilizers (Maheswarappaet al., 1999). Ultimately, it contributes to production of agricultural products and reduces the emission of greenhouse gases (Lorenz and Lal, 2016; Yu et al. 2021). Phenological stage of wheat showed the highly significant variations. The earliest tillering stage (30 DAS each) of wheat was appeared under the application of conventional as well as reduced tillage along with poultry manure (PM), while reduce tillage along with control (no fertilizer) has shown the late tillering (37 DAS). On the other hand, the earliest anthesis stage (101 DAS each) of wheat was appeared under the application of conventional as well as reduced tillage along with poultry manure (PM), while reduce tillage along with control (no fertilizer) has shown the late anthesis (108 DAS). Our results are accord with Arif et al. (2012) who performed a research and revealed that when Farmyard manure, Nitrogen, as well as Biochar were applied at rates of 10 tonne ha-1, 150 kg ha-1, as well as 25ton ha-1, accordingly, they slowed flowering, tesseling, as well as silking. Since evaluating all of the findings, they concluded that the optimal levels for increasing growth of maize are 25 t ha-1for Biochar as well as 5 t ha-1for farmyard manure.

Our findings are also accord with Khan et al. (2021) who showed that the N application had delayed crop phenological phases, and wheat emergence and tillers were enhanced with combine organic and inorganic sources application (FYM, urea and PM) under conservation tillage system.Growth stages also showed highly significant variations. Highest leaf area index and leaf aria durationwere recorded under the application of reduced tillage along with the farmyard manure, while conventional tillage along with control (no fertilizer) recorded the lowest leaf area index. Our results are in line with Yu et al. (2021) who showed that wheat yield, and thousand grain weights and leaf area index were increased significantly under treatments with different tillage systems. Our results showed that maximum crop growth and net assimilation rate rate was recorded under the application of reduced tillage along with the farmyard manure. Our results are in line with Alamzeb at el. (2018) who revealed that organic amendments, tillage systems, and N levels significantly enhanced dry matter partitioning of wheat. Similarly, wheat crop sown with deep tillage showed improved wheat growth than conventional tillage system. The N 125 kg ha-1 and poultry manure (5 ton ha^{-1}) enhance biomass partitioning under deep tillage system in wheat field (Alamzeb at el. (2018).The mixed application of NPS and biochar (organic amendment) significantly affected leaf area index, grain weight, yield and thousands grain weight of maize crop (Tufa et al., 2022). Sohuet al., (2015) showed from their different experimental results that treatments of inorganic fertilizer obtained greater plant height than the organic and control treatments. Application of reduce tillage along with control (no fertilizer), required N from recommended NPK, farmyard manure (FYM), poultry manure (PM), Half of N from recommended NPK + half of N from FYM has shown the number of grains per spike as 53.93, 53.33, 52.6, 53.67 respectively. Thousand grain weight has shown the highly significant variations in response to tillage practices and nutrient management practices. Likewise, interactive effect of tillage practices and nutrient management practices was found significant.Mutegiet al. (2012) found that organic N sources solely resulted in a greater yield of maize grain as compared to mineral sources of N alone. Therefore, they found that naturals are more beneficial over mineral substances in terms of crop improvement as well as health of soil. Our results are also accord with Hussain et al. (2011) who showed that reduced tillage (RT) and conventional tillage (CT) can perform better and produce more grain yield obtained, whereas zero tillage can produce maximum grain yield, improved germination count per unit area, extended spike size, improved plant height, additional productive tillers, heavier thousand grain weight, and higher biological produce.

Grain yield and biological yield has produced the highly significant results in current research. Application of reduce tillage along with control (no fertilizer), required N from recommended NPK, farmyard manure (FYM), poultry manure (PM), Half of N from recommended NPK + half of N from FYM, half of N from recommended NPK + half of N from PM has shown the grain yield as 4.58, 4.15, 4.00, 4.16, 3.52, and 4.07 g respectively. Our results are accord with Farina et al. (2011) who revealed that changing climate as well as farming practices have lowered the soil content across Mediterranean regions, affecting crop yield directly. Results indicated that when sufficient input of C is provided, zero tillage cultivation may effectively confer to increasing soil organic carbon. Our results are aslo accord with Ramadhan et al. (2022) who worked on fertilization and tillage on wheat and soil properties in the heavy soil and found that the maximum seed yield, chlorophyll contents (SPAD, flag leaf) and spike numbers were significantly increased by using organic and inorganic amendments. Further his research indicated positive increase by use of mouldbold plough and tine cultivar in the wheat growth characteristics, yield and yield components and some soil characteristics.

Conclusion

Different strategies like organic mineral and synthetic fertilizers combine with different tillages are used toenhance wheat productivity under semiarid arid agricultureregions. Correspondingly, the hazard ofvolatilization and nitrate leaching reduced efficiently byusing organic amendments and reduced tillage. Current research depictedthe positive effects of organic fertilizers on growth, yield, physiological parameters and phenological stages. The significant improvement in wheat yield was shown with reduced tillage and combine treatments with organic amendments. Itwas showed that reduced tillage performed best than conventional tillage. Future recommendation included that there will dire need to work with mixture of coated farmyard manure and synthetic fertilizers with reduced tillage under drought stress conditions.

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