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Application of Smart Agricultural Practices in Wheat Crop to Increase Yield and Mitigate Emission of Greenhouse Gases for Sustainable Ecofriendly Environment

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Abstract: The present study was based on the hypothesis that "the use of classical farming techniques is the cause of emission of greenhouse gases (GHGs) in the study area, which can be mitigated by employing smart agricultural practices (SAPs)". The study comprises experimental trials, which were carried out over two consecutive years (2020–2021) on two experimental areas (site 1: Koel, site 2: Moel) in District Bhimber of Azad Jammu and Kashmir, Pakistan. Wheat cv. Punjab-2018 was used in the experiment. The experiment was performed in a split-plot factorial arrangement with the main experimental plot bisected into two subplots. Within the two halves of the experimental plot, one side experienced the original tillage practice (PT—-by ploughing at a depth of 4–6 cm; HT—-by harrowing at 12–15 cm; NT—-no tillage, of subsoil or soil ploughing). The subsoiling technique applied included subsoiling ploughing tillage (SPT), subsoiling harrow tillage (SHT), and subsoiling of no-tillage (SNT). Subsoiling was performed by means of ploughing land utilizing a vibrating subsoil trowel to a depth of 14 to 14.5 inches. As a result, each subplot was divided into three replicates. So, a total of six replicates, each 35 m in length and 4 m in width were chosen for the experiment. The results depicted that the influx of CO_x uptake increased in all subsoiling treatments: that is, SPT, SHT, and SNT. The uptake of CO_x was comparatively lower in HT, RT, and NT. In the same manner, GWP for NO_x was recorded to increase when the soil was subjected to subsoiling, that is, HTS, RTS, and NTS. Along with this, the trend of soil temperature and soil content also fluctuated with $R^2 = 0.78$ at $p < 0.01$ from February to April and $R^2 = 0.66$ from December to January, which shows that SAP causes higher emission of NO_x and more uptake of CO_x. Subsoiling maintains soil moisture content (SMC) and soil organic carbon (SOC), which allows limited release of NO_x from soil, maintaining the soil nitrogen content. In the case of SOC and pH, it was found that higher pH causes reduced absorption of CO_x into soil and NO_x emission from soil while higher SOC causes more absorption of CO_x into soil and more emission of NO_x. The application of smart agriculture in the form of subsoiling leads to an increase in the yield of wheat crops and is recommended in agriculture in the context of climate change.

Keywords: smart agricultural practices; soil moisture content; harrow tillage; wheat yield; Bhimber; Azad Kashmir; Pakistan

1. Introduction

Smallholder farming is one of the most powerful and efficient sectors, which not only provides food but also contributes to the economy of different countries around the globe [1]. Farming or agriculture practice is the most common profession in developing countries because a greater population of their rural community depends primarily on agriculture for life sustenance [2]. At the same time, due to traditional practices, the agricultural sector is causing different major environmental strains in the form of emissions of high amounts of greenhouse gases (GHGs) into the air [3]. Incessant addition of such excessive greenhouse houses gasses (GHGs) to the environment is causing drastic alternations to the climate commonly referred to as climate change (CC). Currently, CC has become one of the most dangerous threats to the whole world, affecting the lives of all living organisms and particularly the life of man [4]. Changing climate not only disturbs the gas distribution in the environment but also causes alterations in the temperature, rainfall, and the humidity percentage, and such drastic alterations in the environment directly affect the plant community and its whole ecosystem. The agricultural sector is highly impacted by CC because crop performance and yield are predominantly dependent on environmental factors [5,6]. In conjunction with the impact of CC on yield, the different used techniques also have a pivotal role in the production of crops. In the study area, different conventional soil tillage techniques are being used and among those predominantly used are the ploughing technique (PT) in which ploughing is done at depths of 0.15 to 0.20 inches; the harrowing technique (HT), where harrowing is conducted at 6 inches; and NT, no tillage of subsoil or soil ploughing. The type of tillage use also has a significant impact on the yield of the wheat crop.

To enhance the agricultural yield, various farming techniques are introduced all around the world, consisting of classical to advanced technology, and each has its benefits and hazards. Currently, one such approach known as the smart agriculture practice (SAP) is being used with the aim of utilizing smart agricultural techniques that would produce more yield with lesser GHG emissions [7,8]. In this context, conservation agriculture practices (CAPs) are the most prevalently used around the globe. They involve three major steps: minimum to zero tillage, mulching with crop residue, and crop rotation. CAPs not only increase the yield but also increase soil water holding capacity, increase soil organic content, and produce lesser GHGs with good promising yield [9–11].

Most of the GHGs released from the agriculture sector are due to tillage issues, irrational use of fertilizers, and water-logged soil. Various previous studies have focused on GHGs (CO_x and NO_x) released from various tillage practices. Tillage is performed for planning or leveling the agricultural soil before planting new crops in fields. Varying tillage techniques such as plowing, harrowing, and rotatory tillage disturb the topsoil, which decreases soil carbon, nitrogen, and water content. When soil is leveled using such techniques, it sends more NO_x into the environment and excessive CO_x gases (known as GHGs) are released by agricultural fields into the atmosphere [12]. The lifespan plus amount of GHGs in the atmosphere are directly proportional to the percentage of biological feedback in the troposphere. Farming systems currently in practice are very vulnerable to climatic change. Even an increase of 2 °C in the global average temperature for 2200 could be seen with the lesser emissions scenario (B_1) of the IPCC, with a destabilization of present agricultural coordination [13] depending on the location and adaptive capacity of the land [2,9,13].

CAPs also involve the adaptation of innovative techniques and the use of enhanced breeds or varieties of crops that could tolerate rising environmental stresses. Adaptation measures involve changing crop management, for example, changing plantation dates, use of modified crop varieties, and appropriate soil management techniques. Such adaptations increase the yield up to 7–15% and lead to greater tolerance for environmental changes. The present study focuses on the implication of such techniques to evaluate the efficiency of CAPs on practical levels. Secondly, it pinpoints the amount of NO_x and CO_x that could be reduce by applications of CAPs [2].

The climate change is increasingly a deadly threat to the agricultural and food security of the world. The increase in temperature, irregular rainfall patterns, and increase in heat waves are causing food insecurity like hunger, famines, malnutrition, and persistent poverty. Smart agricultural practices (SAPs) and CAPs are appealing adaptation approaches for the sustainable agricultural production. Some of the peasants do adopt irrational deep tillage practices using machines/tractors, which, directly or indirectly, causes many disorders in soil properties. The common problem of this practice is hardening of the soil, which reduces the aeration and porosity, ultimately culminating in reduced crop yield. In the area investigated in this study, some of the small stakeholders and few large stakeholders have adopted SAPs and CAPs voluntarily but due to the lack of proper information and knowledge, much work and adaptation measures have not been implemented. Moreover, only a few number of farmers are following the SAPs and CAPs approaches due to the lack of proper information in terms of food security and productivity. There is an urgent need of study with focus on providing insight into the workability of such techniques and on establishing recommendations for appropriate approaches that will provide the maximum yield in an eco-friendly form.

The current study was designed (i) to study the impact of the different agriculture practices on the wheat in the study area, (ii) to compare the effects of two agriculture practices, namely CAPs and SAPs, on the yield of wheat to explore the best for the study area, and (iii) to recommend SAPs that will have minimized toxic effects on the climate and provide the maximum agricultural production of wheat in the District Bhimber of Azad Jammu and Kashmir, Pakistan.

2. Materials and Methods

2.1. Experimental Sites and Crop Varieties Used

The present study was conducted in District Bhimber of Azad Jammu and Kashmir, Pakistan (32°58′32.45″ N and 74°04′45.34″ E) situated in the middle of the Shiwalik Mountains Ranges (SMR) of the sub-Himalayan region. District Bhimber is categorized as a dry humid area with an average rainfall of 974 mm, 23.6 °C annual temperature (max 44 °C and min 27 °C), and 5–7 kWh/m^2 solar radiation [14,15]. The soil of the area has loamy characteristics with 32% sand, 40% clay, and 16% silt. The edaphic-physiochemical properties of the sampled soil from the top 0–20 cm comprises the following characteristics: pH 7.89; soil bulk density 1.56 g cm^{-3}; soil organic matter 0.45%; soil total nitrogen 0.11%; and soil total phosphorous 8 %. The experimental field trials were run for three consecutive years (2019–2021) under static experimental parameters. The meteorological data collected from experimental areas are presented in Table 1. The table shows that two parameters, temperature and rainfall patterns, are primarily being affected by climatic changes. The temperature is the key influential parameter that directly or indirectly impacts the other parameters as well. The data of the study were analyzed using parameters like *p*-value, regression analysis, and global warming potential (GWP) through application of dedicated software (Minitab ver.19.2.0. 4, State College, PA, USA).

To evaluate the workability of CAPs, sample plots of the same size were selected from five different areas of District Bhimber of AJK, Pakistan, which were subjected to different experimental trials by employing various tillage techniques. For experimental trials, wheat cv. Punjab-2018 was selected. The irrigation mode and timing were kept constant to analyze the impact of CC on soil constitution and subsequently on yield of crop. The fertilizers with fixed ratio were mixed in the selected sample plots, which were prepared in triplicate and then each part was bisected into two each with different tillage techniques (described in the experimental plot section). Concentration of CO_x and NO_x were calculated before and after subjecting the soil to conservational agriculture practices. Results were statistically analyzed using *p*-value, regression analysis, and global warming potential (GWP) of CO_x and NO_x variables parameters.

Table 1. Soil structure and climatic parameters observed in experimental trial sites (Koel and Moel) from District Bhimber of AJK, Pakistan.

Site 1 (Koel)						
Edaphalogical Features						
Years	Soil Type	Soil pH	Total Organic Carbon (%)	*p*-Content of Soil (mg/L)	Total Saturation Point (%)	Organic Matter Content (%)
2019–2020	Loamy	7.56	10	11	28	0.45
2020–2021	Loamy	7.89	06	08	33	0.31
Climatic Parameters						
Years	Max. Temp (°C)	Min. Temp (°C)	Rainfall (mm)	Humidity (%)	Soil Moisture Content	Solar Radiations (kWh/m^2)
2019–2020	33	21	0.6 mm	33.5	25	5–7 kWh/m^2
2020–2021	31	17	0.5 mm	16.5	22	5–7 kWh/m^2
Site-2 (Moel)						
Edaphalogical Features						
Years	Soil Type	Soil pH	Total Organic Carbon (%)	*p*-Content of Soil (mg/L)	Total Saturation Point (%)	Organic Matter Content (%)
2019–2020	Loamy	7.90	11	12	27	0.42
2020–2021	Loamy	8.00	5	09	30	0.29
Climatic Parameters						
Years	Max. Temp (°C)	Min. Temp (°C)	Rainfall (mm)	Humidity (%)	Soil Moisture Content	Solar Radiations (kWh/m^2)
2019–2020	32.5	18	0.8 mm	31.5	23	5–6 kWh/m^2
2020–2021	32.0	19	0.6 mm	14.5	20	4–6 kWh/m^2

2.2. Determination of Conc. of Different Soil Gases

For determination of soil concentrations of emitted gases, the modified method of dry combustion with spectrophotometric analysis was used. The weight of soil samples was combusted for 30 min at 160 °C [16,17]. In respective aspects, about 100 mL of the sample was placed in a conical flask along with 5 mL of chromous mixture (consisting of 0.2 M potassium dichromate within (1:1) dil. H_2SO_4) following standard protocols [18–20]. A thermostat was used to facilitate the lowering of temperature. At 160 °C temperature, the combustion rate of thermostat and products were measured. The titration method was employed because it was rapid with no special requirements. Surplus amount of dichromate was used along with Mohr's salt solution (0.1–0.2 M) during titration. Then the sample was removed from the heating chamber and set to cool. Precautionary measures were taken to avoid overheating of the experimental samples. The sample content from the heat chamber was shifted to a 50 mL flask after cooling it. The solution was left overnight and subjected to spectrophotometry for calculations. The spectrophotometer was set at a wavelength of 325–1000 nm (accuracy ±2 nm) to measure absorption spectra of different soil samples. The measurement interpretations were shown on a digital screen; the operation of the instrument was straightforward and user-friendly. Quartz glass cuvettes of 1 cm diameter were used for the work and 590 nm wavelength was used for analytical measurements.

2.3. Study Area Description

The study was conducted in Tehsil Barnala of District Bhimber (AJK), Pakistan, in the selected agriculture trial centers with phytogeographic dimensions of 32°58′ to 32.45″ N and 74°04″ to 45.34″ E. The study sampling sites comprised representatives from the whole area of District Bhimber.

2.4. Experimental Design for Analysis of Agriculture Techniques in Soil

The experimental scheme was designed and set so as to evaluate the impact of agricultural techniques on soil structure. Among the agricultural techniques, different tillage practices were evaluated during the course of study. It was hypothesized that shallow tillage methods cause greater absorption of CO_x and NO_X type gases in soil; hence, affecting the yield of crop sown in the soil. The experiment was performed in split plot factorial arrangement with a main experimental plot bisected in two subplots. There were two halves of the experimental plot; on one side, the original tillage practices (PT—-by ploughing at depth of 4–6 cm; HT—-by harrowing at 12–15 cm; NT—-no tillage of subsoil or soil ploughing) were employed. While on other side, subsoiling techniques were applied (subsoiling ploughing tillage (SPT), subsoiling harrow tillage (SHT), and subsoiling of no-tillage (SNT)). Subsoiling was performed by the ploughing of land utilizing a vibrating subsoil trowel to depths of 14 to 14.5 inches. As a result, each subplot was divided into three replicates, so a total of six replicates each having 35 m length and 4 m width were chosen for the trial experiment.

2.5. Trial Crop Cultivation

The wheat was sown in late October immediately after tilling the soil and was harvested in middle to late April of each experimental season. The wheat was supplemented with fertilizer three times during the cropping season with a ratio of 210 phosphorous kg N/ha at seedling stage for proper growth and development; 100 kg/ha of P_2O_5, 90 kg/ha^{-1} K_2O, and 95 kg/ha nitrogen were used along with proper irrigation with 130 mm amount.

2.6. Sampling and Measurement of CO_x and N_2O

To determine the concentrations of CO_x and N_2O in the field, dry combustion or elemental analyzation procedure was utilized [21,22]. The collection of soil samples was performed after every one-month interval. The soil was collected from 30 cm depth from each experimental plot. For the measurement of CO_x soil was collected during the morning around 8:00 am to 10:00 am, while for N_2O measurement, the soil was collected from 9:30 am to 12:00 pm [6]. The collected soil samples consisted of carbon content in three forms: organic, inorganic, and in form of charcoal. Before its analysis, all visible residues were removed from the samples, and they were subsequently analyzed. The soil surface temperature and atmospheric temperature were also measured. The concentrates of CO_x and NO_x were checked and measured after every 5, 25, and 40 min (after the temperature of the chamber reached 160 °C) along with changing the temperature of the chamber regularly. The emission changes in CO_x and N_2O were calculated using the following formula [6,21,23].

$$F = \frac{60HMP}{8.314(273 + T)} \frac{dc}{dt}$$

where F is the change in gas emission or uptake (μg·m^{-2}·h^{-1}); 60 is the conversion coefficient of minutes and hours; H is the height (m); M is the molar mass of gas (g·mol^{-1}); p is the atmospheric pressure (Pa); 8.314 is the Ideal Gas Constant (J mol^{-1} K^{-1}); T is the average temperature in the static chamber (°C); and dc/dt is the line slope of the gas concentration change over time.

2.7. Measurement of Global Warming Potential of CO_x and N_2O

The changing climatic conditions due to global warming has revealed that the highest percentage of GHGs are emitted by the agricultural sector. Mostly, these GHGs include CH_4 and NO_x, which are released into the environment due to microbial and chemical reactions occurring between atmospheric gases and soil gaseous emission (by fertilizers added to soil). Various agricultural practices, such as tillage practices, increase the ratio or percentage of the respective gases in the environment. It has been estimated that the global warming potential (GWP) of CH_4 and NO_x are higher (25 and 298, respectively) compared to CH_4 (which is 1). The potential of CH_4 and NO_x causing the global warming is calculated using following formula [6,12].

$$\text{GWP}\ (\text{CH}_4) = \frac{\text{TF}(\text{CH}_4) \times 1}{100}$$

$$\text{GWP}\ (\text{NO}_x) = \frac{\text{TF}(\text{NO}_x) \times 298}{100}$$

In the equations, GWP (CH_4) and GWP (NO_x) represent CH_4 and NO_x in kg CO_2/ha, TF represents the total uptake of CH_4 and NO_x (kg CO_2/ha/area), 25 represents CH_4 GWP coefficient, and 298 represents that of NO_x, while 100 is the time scale for changing climate.

2.8. Measurement of Soil Factor

Climatological information during the course of the experimental trial was gathered from the nearby meteorological station of Lahore. To estimate of the relationship between soil temperature (ST) and soil moisture, the content in contrast to CH_4 and NO_x production were analyzed. The ST was calculated from 5 cm depth of soil whereas for calculating SMC, the soil was taken from 0–25 cm depth. The soil temperature was measured by a thermometer while for soil moisture content (SMC) measurement dry air gravimeter was used [24,25] and for soil texture analysis, Robinson's pipette method was employed [26]. The core sampler was used for determining the soil bulk density (BD), following the protocol of previous research works [26,27]. The available nitrogen was estimated by the alkaline permanganate method [28]. The Olsen's method was employed for determination of available phosphorus (P) [29,30], which was used in proper form with some minute modifications while potassium (K) content was determined through the flame photometry protocol [30]. The soil and water suspension with constant ratio (1:1) was used for estimation of the soil pH by pH meter [31,32]. For analysis of soil organic matter (SOM) in the samples, the acid digestion method was utilized [32,33]. The current climatic scenario and edaphalogical characteristics of two study sites are presented in tabular form (Table 1).

3. Results

For the analysis of effects of different agriculture practices and release of different GHGs in these experimental plots, various experimental trials were conducted in triplicate. In the study, one parameter, number of spikelets per stalk, grains number, and total yield of the wheat crop were measured from the middle portion of each plot in triplicate to maintain the consistency and reliability of the experiment. Generally, three replicas of each plot were evaluated for every parameter. The data were statistically analyzed through the Past software and Minitab (Version: 19.2.0, Coventry, UK) software using sigma plot value. For pinpointing the difference between two sets of tillage practices, mean standard deviation and least significant features were calculated.

3.1. Measurement of CH_4 and N_2O Gases Concentration

In the experimental plots where harrow, plough, and no tillage practices were used, the amount of CH_4 influx observance was 12.89 $\mu g \cdot m^{-2} \cdot h^{-1}$ for ploughing tillage, 14.67 $\mu g \cdot m^{-2} \cdot h^{-1}$ for harrowing tillage, and 8.01 $\mu g \cdot m^{-2} \cdot h^{-1}$ for no tillage. When tillage was shifted to subsoil, the content of CO_x observance differences were 13.53 $\mu g \cdot m^{-2} \cdot h^{-1}$ to 15.67 $\mu g \cdot m^{-2} \cdot h^{-1}$ for PTS, from 14.67 $\mu g \cdot m^{-2} \cdot h^{-1}$ for RT to 17.99 $\mu g \cdot m^{-2} \cdot h^{-1}$ from RTS, and from 8.01 $\mu g \cdot m^{-2} \cdot h^{-1}$ for NT to 10.55 $\mu g \cdot m^{-2} \cdot h^{-1}$ from NTS, respectively (Table 2, Figure 1). The increase in NO_x influx was observed when soil was shifted from being subjected to no tillage (27.15 $\mu g \cdot m^{-2} \cdot h^{-1}$) to NTS (51.27 $\mu g \cdot m^{-2} \cdot h^{-1}$) (Table 2, Figure 1).

Table 2. Different tillage practices performed in six different plots and mean absorption of CH_4 and emission of NO_X.

Agricultural Practice	Ploughing Tillage (μg·m^{-2}·h^{-1})	Harrow Tillage (μg·m^{-2}·h^{-1})	No-Tillage (μg·m^{-2}·h^{-1})	Plowing Tillage Subsoiling (μg·m^{-2}·h^{-1})	Harrow Stillage Subsoiling (μg·m^{-2}·h^{-1})	No-Tillage Subsoiling (μg·m^{-2}·h^{-1})
CH_4	12.89	14.67	8.01	15.67	17.99	10.55
NO_x	47.10	44.60	27.15	52.45	51.77	51.27

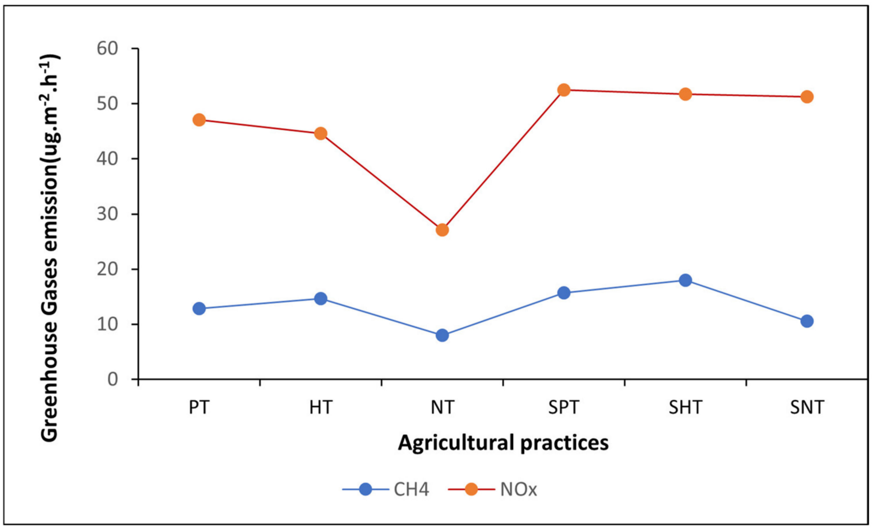

Figure 1. Graphical representation of the GHGs emission from wheat growing season (October–April) from soil subjected to deep tillage and subsoiling from sample plots designed in District Bhimber of AJK, Pakistan. PT: plough tillage; HT: harrow tillage; NT: no tillage; SPT: subsoiling ploughing tillage; SHT: subsoiling harrow tillage; and SNT: subsoiling of no tillage.

3.2. Measurement of Global Warming Potential of CO_x and N_2O

The concentration of CO_x was calculated using the formula of GWP as mentioned above. The results show that the influx of CO_x uptake increases in all subsoiling treatments: i.e., SPT, SHT, and SNT. The uptake of CO_x was comparatively lower in HT, RT, and NT. In the same manner, GWP for NO_x was recorded to increase when soil was subjected to subsoiling, i.e., HTS, RTS, and NTS (Table 3).

Table 3. Analysis of Global Warming Potential of CO_x and NO_x produced at six experimental plots designed in District Bhimber of AJK, Pakistan.

Agricultural Practice	Ploughing Tillage (μg·m^{-2}·h^{-1})	Harrow Tillage (μg·m^{-2}·h^{-1})	No-Tillage (μg·m^{-2}·h^{-1})	Plowing Tillage Subsoiling (μg·m^{-2}·h^{-1})	Harrow Stillage Subsoiling (μg·m^{-2}·h^{-1})	No-Tillage Subsoiling (μg·m^{-2}·h^{-1})
CH_4	−0.73	−0.81	−0.62	−0.70	−0.34	−0.55
GWP for CH_4	−0.13	−0.18	−0.15	−0.14	−0.09	−0.12
NO_x	2.10	2.40	2.15	2.45	1.37	2.27
GWP for NO_x	0.45	0.54	0.51	0.55	0.33	0.60
Total emission of both gases	1.31	1.53	1.59	1.64	1.05	1.91
GWP of both gases	0.29	0.35	0.34	0.36	0.25	0.42
Increase in emission after subsoiling	–	0.15	–	0.05	–	1.05
Increase in GWP after subsoiling	–	0.04	–	0.01	–	0.21

3.3. Correlation Analysis between CO_x and N_2O and Soil Factors

It was noted that when the temperature fluctuates, increases from February to April or decreases from October to mid-January, the soil moisture content also changes. The moist or wet soil releases more NO_x gases in the air as compared to the partially moist soil. Furthermore, the wet soils also release varying forms of carbon containing oxides, which add to the global warming process. During the experiment, the soil temperature along with moisture content of soil was calculated as part of a quantitative analysis to determine the impact of changing temperature, soil moisture content, and the emission of carbon and nitrogen containing various gases. On a monthly basis, ST and SMC concentrations were analyzed. The values were arranged in tabular form and then analyzed using R^2 and probability test with ($p < 0.05$ and $p < 0.01$) (Table 4).

Table 4. Statistical analysis between varying influx of selected gaseous in accordance with changing soil temperature and soil moisture content.

Soil Factors	**Soil Temperature (ST)**		**Soil Moisture Content (SMC)**	
Gaseous Emission	CO_x	NO_x	CO_x	NO_x
Statistical Tool	R^2	*p*-Test	R^2	*p*-Test
21.10.19	0.89	0.03	0.50	0.04
21.11.19	0.67	0.03	0.64	0.03
21.12.19	0.78	0.02	0.54	0.04
21.01.20	0.67	0.01	0.54	0.04
21.01.20	0.66	0.02	0.09	0.03
21.02.20	0.58	0.05	0.52	0.02
21.03.20	0.78	0.06	0.41	0.02
21.04.20	0.89	0.05	0.51	0.01

From October to mid-January, more water content was noticed due to increased humidity in the air and soil as compared to February to April. The values of $R^2 = 0.78$ $p < 0.01$ were recorded from December to January, $R^2 = 0.66$, $p < 0.01$ and were higher during April ($R^2 = 0.89$, $p < 0.01$). Statistically, the results depicted that SMC causes higher emission of NO_x and more uptake of CO_x by soil. The more absorption of CO_x in soil negatively affects the growth of spikelets and grains production of the wheat. The excessive emission of NO_x causes nutrition deficiencies in crops due to lower nitrogen content.

In case of soil organic content (SOC) and pH, it was evaluated that higher pH causes reduced absorption of CO_x in the soil and NO_x emission increases from the soil. SOC works against pH, i.e., a higher SOC value causes more absorption of CO_x in the soil and more emission of NO_x, hence maintains an optimum level of both gases, which facilitates proper crop growth (Figure 2A,B).

In all the experimental plots, it was noticed and statistically proved that the soil factors changed when experimental plots were subjected to subsoiling. These changing soil parameters caused great influence on the growth and performance of the wheat. In each plot, the yield was calculated to analyze which agricultural technique was reliable to get high value yield and lower emission of harmful gases that cause global warming. The yield per year and difference between both sets of agricultural practices are shown in Table 5.

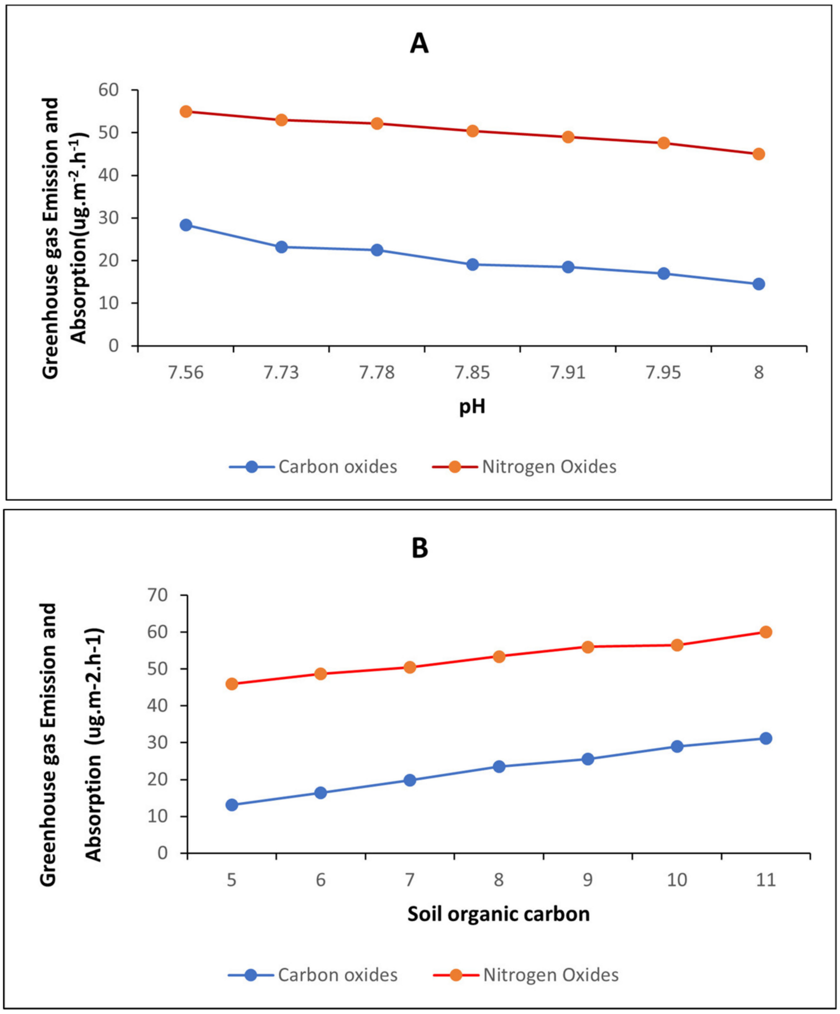

Figure 2. (**A**): Absorption of CO_x and emission of NO_x from soil with changing pH from all experimental plots. (**B**): Absorption of CO_x and emission of NO_x from soil with changing SOC from all experimental plots.

Table 5. Yield, spikelet per stalk, and grain per ear recorded from each experimental plot during 2020 and 2021 from District Bhimber AJK, Pakistan.

Agricultural Practice	Ploughing Tillage ($\mu g{\cdot}m^{-2}{\cdot}h^{-1}$)	Harrow Tillage ($\mu g{\cdot}m^{-2}{\cdot}h^{-1}$)	No-Tillage ($\mu g{\cdot}m^{-2}{\cdot}h^{-1}$)	Plowing Tillage Subsoiling ($\mu g{\cdot}m^{-2}{\cdot}h^{-1}$)	Harrow Stillage Subsoiling ($\mu g{\cdot}m^{-2}{\cdot}h^{-1}$)	No-Tillage Subsoiling ($\mu g{\cdot}m^{-2}{\cdot}h^{-1}$)
			2020			
Spikelets per stalk (cm)	245.8	266.7	179.4	249.8	257.5	290.8
Grains per ear	29.8	30.08	24.54	31.87	32.09	35.12
Total yield (kg/ha)	4662.10	4442.40	4441.87	4962.45	4852.37	4562.27
			2021			
Spikelets per stalk (cm)	256.4	265.4	178.1	268.5	279.3	299.60
Grains per ear	22.31	24.53	20.59	27.64	28.05	31.91
Total yield (kg/ha)	4612.29	4333.78	4451.34	5113.89	5014.15	4915.52

The results show that crops rotation, use of modified wheat variety, and subsoiling technique led to a higher yield with an HT tillage practice as compared to PT and NT. The significant increase was not only noticed in annual yield but was also recorded for the number of grains and spikelets per stalk (Table 5).

4. Discussion

Agriculture is the backbone of the economy in agriculture-based countries and it provides the pivotal necessity of mankind, food. Agriculture is being affected by changes of climate and yield of wheat and other cereals are severely damaged. Climate change (CC) is the key issue of world and it hampers both food quantity and quality. Secondly, rural areas are using conventional agriculture methodologies for cultivation of various crops and the irrational use of fertilizers and other plough techniques is itself impacting CC. In this comparative study, commonly used methods by indigenous peoples were evaluated and their correlation with CC and yield paradigm of wheat was determined.

Subsoiling leads to changes in the structure and porosity of the soil that ultimately leads to more diffusion of gases in the soil. The increase in methane absorption with subsoiling might be due to an increase in soil temperature due to subsoiling. However, increased emissions in NO_x are also being documented with subsoiling treatment. This increased emission is due to an increased denitrification process after irrigating the wheat, as irrigation decreases the soil pH. The experimental results proved that soil subjected to deeper tillage or no tillage causes hardening of the soil, which reduces the soil bulk density and ultimately impacts the yield of the wheat [6,34]. Whereas subsoiling techniques are proven more effective in many aspects, they positively change the soil structure by increasing soil gaseous holding capacity and diffusion in arable lands. During the course of study, an experimental trial was set in which PT was subjected to PTS, H to HTS, and NT to NTS, and the results were very fruitful and promising in terms of yield potential of wheat. The results showed increase in CO_x absorption and promotion in the emission of NO_x. The enhanced CO_x absorption in soil was significantly correlated to soil temperature, SMC, soil pH, and SOC (Figure 2A,B and Table 4), which were in line with analysis of previous researchers [35–37]. A higher temperature and greater SOC may be advantageous to increasing the amount of CO_x absorbed by the soil (Table 2, Figure 2A) and these findings were congruent with past works conducted by various researchers [6,38,39].

GWP analysis of respective gases showed that concentration of both gases increased in all soil samples subjected to subsoiling. The subsoiling maintains SMC and SOC, which allows limited releases of NO_x from soil maintaining soil nitrogen content. Along with this, subsoiling also causes lower emissions of NO_x to the environment and balances the environmental gaseous concentration. In the same manner, it adjusts the CO_x concentration in the soil samples. In case of soil organic content (SOC) and pH, it was showed that higher pH causes reduced absorption of CO_x in soil and NO_x emission from soil. The SOC works against pH, i.e., a higher SOC value causes more absorption of CO_x in soil and more emission of NO_x, which was in line with the previous findings of Huang et al. [40].

The compaction influences the properties of soil such as dry density, cone index, and total porosity. Similarly, the compaction decreases the available water contents to the roots of plants. The application of smart agricultural techniques is useful in increasing the air permeability, macro porosity, and hydraulic conductivity. Subsoiling increases the availability of water and soil nutrients are mobilized and become readily available to the plants. Furthermore, subsoiling increases root density and proliferation. All of these subsoiling-mediated alterations eventually affect plant yield. Additionally, subsoiling is responsible for delay in leaf senescence after the flowering period. The study showed that change of agricultural practice from PT, HT, and NT to PTS, HTS, and NTS resulted in about 8.7% higher yield in the small experimental plot. Along with this, subsoiling was also proven to be beneficial in increasing the spikelets per stalk and grains per ear of wheat. Subsoiling has been proven beneficial on a commercial level for producing more yield as well as on an environmental level as it produces less NO_x emission and higher Co_x absorption in the soil. Subsoiling is an efficient technique used previously by a number of researchers owing to its tremendous outcomes [40]. This all indicates that SAPs and, preferably SAPs agriculture approaches, provide good wheat yield and they are also ecofriendly because they assist in mitigating GHGs emission from the soils and other debris of agriculture crops that remains in the fields. This research recommends further work to be conducted to investigate the detailed impact of CC and correlation of SAPs approaches to meet the necessities of food in the world as the population of the world increases at an alarming pace.

5. Conclusions

The agricultural sector is a major producer of harmful gases let into the air, which causes global warming, hence altering the climatic conditions worldwide. The present study presents a quantitative approach by introducing ecofriendly agricultural practices. Subsoiling is pointed out to be an ecofriendly and increased grain producer technique. The results from the experimental trials and statistical analysis proved subsoiling as a climate resilient and smart agricultural technique, which will give more significant outcomes. The technique causes lower emission of nitrogen compounds in the environment; hence, it maintains the soil nitrogen content and facilitates more carbon absorption in the soil. These results are very promising in terms of lowering the GWP in the agricultural sector. Furthermore, subsoiling also had significant impacts on soil structure such as that it increases SOC, SMO, and soil pH to actively maintain the soil gaseous level. In these aspects, the study suggests converting tillage to subsoiling in order to overcome the climatic issues. It is recommended to use smart agricultural approaches to mitigate the agriculture residues' pollution, which enhances CC hazardous impacts. The application of the latest smart agricultural techniques is needed in the context of CC and food security.

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