Research Article

Planting Technique and Integrated Nutrient Management in Deep Tillage for Manipulating Wheat yield

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Abstract | Deep tillage, is performing tillage operations below 20 cm depth, has countless benefits in rainfed areas but the recent problem in the deep tillage is the loss of nutrients. Various techniques have been studied for declining the loss of nutrients. Therefore, this research was carried out in the University Research Farm, The University of Agriculture Peshawar, Pakistan to find the effect of raised seed bed dimensions and integrated nutrient management on the yield of winter wheat (*Triticum aestivum*) cultivar (*Pirsabak 2015*) under deep tillage in silt clay loam (*Pedocals*) soil during 2019. The levels of planting technique factor were; 0 m high raised seed bed (P1), 10 cm high raised seed bed (P2) and 20 cm high raised seed bed (P3). Compost from domestic residues (C2), a combination of urea with compost (C3), and urea (C4) were compared with control, no N-fertilizer (C1) in integrated nutrient management factor. The result showed that the treatments had a significant effect on the plant height, spike m^{-2}, grains $spike^{-1}$, grain yield, biological yield, and harvest index. The highest plant height (0.44 m) and spike m^{-2} (88) were found in the combination of P3 with C2. The highest grain yield (3298 kg ha^{-1}) was recorded in the combination of P2 and C3. The highest biological yield (9144 kg ha^{-1}) was found in P1 with C3. Though the highest grains $spike^{-1}$ (89), thousand-grain weight (45 g) and harvest index (39.91%) were calculated in the combination of P1 and C4. Almost all the parameters gave the lowest recorded value in the combination of P1 with C1. The research concluded that the combination of compost with urea and raised seed bed are the better option for enhancing the wheat yield under deep tillage.

Received | September 07, 2021; **Accepted** | November 02, 2021; **Published** | July 04, 2022
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Citation | Haq, I.U., M. Ramzan, M.K. Khattak and A. Khan. 2022. Planting Technique and Integrated Nutrient Management in Deep Tillage for Manipulating Wheat yield. *Sarhad Journal of Agriculture,* 38(3): 841-850.
DOI | https://dx.doi.org/10.17582/journal.sja/2021/38.3.841.850
Keywords | Fertilizer, Flat bed, Grain yield, Plant height, Raised seed bed, Wheat

Introduction

Wheat is a staple food all over the world. It is grown in almost all environments in Asia and East Africa. Different varieties have been developed to achieve maximum growth and yield of wheat (Majeed *et al*., 2015). It contains about more than 70% of starch, 10% protein, 4% fat, and provides 370 Kcal (100 g^{-1}). It is consumed by various processing methods (Peter *et al*., 2014). Wheat flour adds 72% of Pakistan's daily caloric intake. It is the main Rabi season growing crop cultivated at about 9 million hectares (about 40% of the total cultivated area) in Pakistan. Wheat contributes about 10 percent of value-added in Agriculture and 2.2% to the gross domestic product. In Pakistan, its yield per hectare is much lower than the other wheat-producing countries (FAO, 2017). The yield of wheat depends on different factors *i.e.* physical, chemical, biological, and mechanical (Nair *et al*., 2015). It is grown by the broadcasting method and by using a seed drill keeping 20-25 cm distance between the rows with sowing depth of 2 inch. Enhanced irrigation systems and soil management are the key points for improving water use efficiency (WUE) and fertilizer use efficiency (FUE). Wheat yield becomes higher by adopting a modern technique of planting, named it raised bed (Majeed *et al*., 2015).

Among sustainable agriculture techniques, a trend of adopting a better method of planting technique has become familiar. Various planting techniques have been applied for achieving a high yield of crops. The planting technique has a significant effect on the growth and developmental stages of a crop. Raised bed and ridge-furrow sowing techniques are widely used for improving crop yield in the developed countries. The raised improves irrigated wheat-based cropping systems by using fewer resources and enhances crop yield results in sustainable agriculture. It has many advantages over the flatbed planting technique. It decreases the cost and time for the management of fertilizer, water, and weed control (Khan *et al*., 2012). Raised bed with furrow mulching significantly increases water use efficiency and wheat yield. Raised bed with mulch is first developed in Mexico (Kashif *et al*., 2018). It enhances developmental stages and biomass production by decreasing the time duration for completing phonological stages and thus enhances the production of biomass and grain yield (Singh and Singh, 2019). The conventional planting technique is referred as flat sowing. In comparison with raised bed sowing, flat sowing technique resulted in less growth and yield of a crop (Mohsin *et al*., 2019).

The soil-nutrient enhancing factor is the use of fertilizer. Almost a major portion of Pakistan's soil, have a deficiency of plant requiring nutrients. N-Fertilizer may be in the form of inorganic such as urea or organic such as farmyard manure, compost *etc*. The addition of organic matter to the soil enhances its physicochemical properties (Bahrani *et al*., 2017). Different organic sources have been used for retaining moisture and increasing the ionic capability of soil particles. The use of compost is valuable to enhance organic matters in the soil. It consists of plants requiring elements at an optimum proportion enhances the soil properties (Schulz and Glaser, 2012). The use of poultry manure significantly increases the crop yield (Inal *et al*., 2015). The rice and wheat residues when burned in the field after grain harvesting, also resulted in a significant increase in the soil properties. A similar result was found when the fruits and vegetable wastes were collected and incorporated in the soil (Kamkar, 2014)

Lack of resources in traditional farming methods, environmental catastrophe and drought has negatively affected sustainable agriculture (He *et al*., 2016). Soil surface covering with mulch have a significant effect on the soil physio-chemical properties. It reduces surface runoff, conserving moisture content within the soil particles, decreasing root penetration resistance, enhancing the infiltration of water and thus reduces the chance of soil erosion (Zhang *et al*., 2016). Various materials have been applied in the field as mulch *i.e.* plastic, agricultural waste, stone or other inorganic materials. Maize straw has many advantages regarding soil and crop parameters when used as mulch (Xue *et al*., 2019). It has a capacity of absorbing the kinetic energy of rainfall, decrease the possibility of soil crusting after heavy rain. Mulching and deep tillage showed a significant effect on enhancing the yield of crops under rain-fed condition (Yifu *et al*., 2016).

In deep tillage, nutrients losses occur frequently. This may prohibit increase in yield of the crop. To reduce the leakage of nutrients, various planting techniques and integrated nutrient management may act as positive factors. To achieve high yields and production of wheat optimum planting techniques and integrated nutrient management should be adopted. The objectives of the study were to find the effect of planting techniques and integrated nutrient management on the wheat crop under deep tillage.

Materials and Methods

Site description and experimental design

The research study of the effect of planting techniques and integrated nutrient management on the wheat crop was performed at University Research Farm, the University of Agriculture Peshawar, Pakistan during

2019. The soil had a texture of sandy clay loam soil with sand, clay, and silt of 19.1%, 32.9%, and 48.5% respectively. The soil descriptions (physio-chemical characteristics) before applying treatments and tillage are as given in Table 1. Two factors were applied in this study *i.e.* raised seed bed (PT) and integrated nutrient management (INM). The total numbers of treatments in the study were 12 and were run with three replicates. The levels of PT were: Control (0 cm height) – P1, Raised seed bed of 10 cm height – P2, Raised seed bed of 20 cm height – P3. The levels of INM were: Control (No N-fertilizer) – C1, Compost (100%) – C2, Compost (50%) + inorganic fertilizer (50%) – C3, Inorganic fertilizer (100%) – C4.

Table 1: Description of soil used for the experiment.

Depth	Parameter	Reading
0-20 cm	Penetration resistance	445 N cm^{-2}
	Bulk density	1.72 g cm^{-3}
21-40 cm	Penetration resistance	492 N cm^{-2}
	Bulk density	1.83 g cm^{-3}
0-30 cm	pH	7.7
	EC	0.54 dS m^{-1}
	Total N	15.91 %
	Total P	2.11%
	K	80.75 %

Procedure

The total experimental field was 756 m^2 and the plot size for each treatment was 2.1×10 m^2. Winter wheat (cultivar *Pirsabak 2015)* with a seed @ of 120 kg ha^{-1} was used in this experiment. The plot for wheat was kept constant in flat and raised seed bed throughout the research. Row to row distance for wheat was 25 cm. Wheat seed was sown in 3rd December 2019 by using a seed drill of 08 rows in each plot. The seeds were sown at 2 inch depth in all the plots. The plots were fully mulched by maize straw at a rate of 1400 kg ha^{-1} to conserve water (Yifu *et al*., 2016). All the variables kept constant throughout the experiment in all plots. Meteorological data for the experimental site were collected from the Department of Weather Regional Station Peshawar as shown in Figure 1. The crop was harvested at 21st May 2020. The parameters recorded in the study were:

Plant height (m): At maturity stage, plant height in each treatment was measured in meters of randomly selected five tillers.

Spikes m^{-2}: At physiological maturity stage, spikes per square meter was find out by counting number of spikes at three different places in a row and then their average was divided by area. Area was calculated by multiplying number of rows, row to row distance and row length.

Grains $spike^{-1}$: Grains per spike were calculated by selecting randomly five different spikes in each experimental plot and average was found out. Its average was then divided by area.

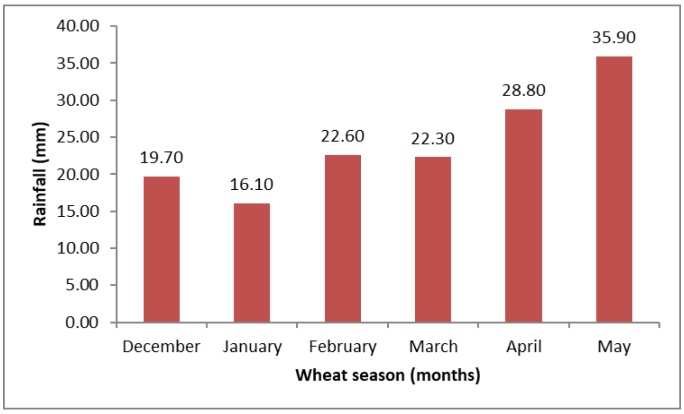

Figure 1: *Rainfall data (mm) for wheat season during 2019-2020.*

Thousand-grain weight (g): Thousand grain weights was recorded by counting five samples of 1000 grains in each plot and then was weighed with the help of digital balance and average was worked out.

Biological yield (kg ha^{-1}): Data on biological yield was recorded after harvesting the crop from five central rows, was then sun dried and converted into yield per hectare.

Grain yield (kg ha^{-1}): Data on grain yield in kilogram per hectare was recorded by threshing the five selected central rows harvesting from the plots. The grains were collected, dried and weighed. The average grain yield was divided by area and then multiplied by 1000. The area was calculated by multiplying number of rows, row to row distance and length of row.

Harvest index (%): Harvest index is the ratio of grain yield to biological yield. The calculated harvest index was then multiplied by 100.

Planting Technique

Three different seed beds were prepared *i.e.* raised bed of 0 cm height (flat seedbed) (P1), raised bed of 10 cm height (P2), raised bed of 20 cm height (P3) keeping soil surface normal. The width of the bed was 2.4 m and the furrow width was 0.9 m. Seeds were sown in the raised bed in such a way that the distance of the plant from either side of the bed was 0.01 m (Majeed *et al*., 2015). The number of rows of wheat was 08 in each plot.

Integrated nutrient management

Domestic residues (organic refuse) were collected by the University Research Farm, the University of Agriculture Peshawar. The compost had been prepared in aerobic conditions. Almost all types of compost have a large number of N, P, and K. The prepared compost was analyzed for its nutrients by collecting 6 random samples from the compost and their average was found. The compost description is given in Table 2. The clean compost from inert materials was dried in oven at 70 °C and then grounded using mesh size of 0.02 mm using grinder. pH of compost was measured in a suspension of compost and water (1:5) after half an hour of stirring using pH meter. The compost electrical conductivity was measured by EC meter as suggested by Sher *et al*. (2018). The P and K in the soil were estimated by using atomic absorption spectrometer and flame photometer. The soil N was measured by using kjeldhal procedure described by Sher *et al*. (2018).

Table 2: *Description of compost used in the experiment.*

Parameter	pH	EC	Total N	Total P	K
Reading	8.1	1.03 dS m^{-1}	0.01 %	0.007 %	2.5 %

The required Nitrogen is 120 kg ha^{-1} for wheat optimum production and is used conventionally. Nitrogen was kept constant throughout the experiment. Keeping nitrogen constant, the required amount of compost (ton ha^{-1}) was calculated by the ratio of 12,000 to the analyzed percent Nitrogen found in the compost. The amount of compost applied in the plots of compost sole was 20 kg/plot in 1st November 2019. Half of the recommended dose of nitrogen was applied at sowing while half was at the 1st irrigation. The prepared compost was applied to the field one month before planting (Florian *et al*., 2019). Necessitated phosphorus and potash amount were fulfilled by using phosphorus and potash fertilizer throughout all the plots. A full dose of recommended phosphorus was used at the time of seeding.

In combination of compost and inorganic fertilizer (50%:50%), available nitrogen-fertilizer was added to the compost so that the combination fulfills the required nitrogen (120 kg ha^{-1}) level. In inorganic fertilizer, Urea (0.25 kg $plot^{-1}$) was used to fulfill the required N. The nutrients (NPK) dose applied was 120:60:30 kg ha^{-1} throughout the plots.

Bulk Density of Soil: The soil bulk density was found from soil samples from 0-20 cm depth and 21-40 cm depth by using core sampler before performing research. The soil was oven dried at 105 °C for 24 hours and then bulk density of soil was calculated by using formula as mentioned by Michal (2014).

$$\text{Soil bulk density} = \frac{\text{weight of oven dried soil (g)}}{\text{Total volume of soil sample (cm}^3\text{)}}$$

Penetration Resistance of Soil: The soil penetration resistance was found by using hand cone penetrometer at 0-20 cm depth and 21-40 cm depth before research. In screen it showed the force applied on the soil in Newton. The force was divided by its cone base area (1 cm^2) as described by Michal (2014).

Soil pH and EC: The clean soil from inert materials was dried in oven at 70 °C and then grounded using mesh size of 0.02 mm using grinder. pH of soil was measured in a suspension of soil and water (1:5) after half an hour of stirring using pH meter. The soil electrical conductivity was measured by EC meter as suggested by Sher *et al*. (2018).

Soil nutrients (NPK): The P and K in the soil were estimated by the procedure described by Sher *et al*. (2018) using atomic absorption spectrometer and flame photometer. The soil N was measured by using kjeldhal procedure.

Statistical analysis

Total of 36 observations was used in RCB design with split plot arrangement to determine which treatment may give the best result. The significance of differences among the treatments was analyzed by Linear Regression Analysis (LRA). Statistical significances were set at a p-value of <0.05 (Liu *et al*., 2014).

Results and Discussion

Plant height

The result showed that the treatments had a significant effect on the plant height. The highest plant height (0.44 m) was recorded in the treatment P3C2 (a combination of 20 cm high raised bed and compost application) while the lowest (0.16 m) was found in P2C1 (a combination of 10 cm high raised bed and no-fertilizer) as shown in Figure 2. The recorded highest plant height was 0.38 m, 0.38 m, and 0.44 m in flatbed (control), 10 cm high raised bed, and 20 cm high raised bed respectively in the application of compost (100%) to fulfill the nitrogen requirements. Similarly, the lowest plant height found was 0.18 m, 0.16m and 0.21 m flatbed (control), 10 cm high raised bed, and 20 cm high raised bed respectively in the no-fertilization application. The results coincide to the Shahzad *et al.* (2019), they stated that plant height is significantly affected by the planting techniques. Same results were found by Kashif *et al.* (2018). They stated that the seeds sown in flatbed give lesser plant height than the seeds sown in-furrow and raised bed. The mean difference in the plant height sown in various planting techniques reaches up to 12%. The results are further supported by Singh and Singh (2019).

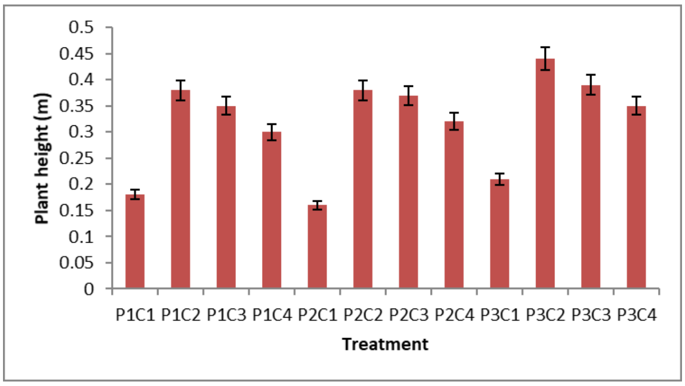

Figure 2: *Plant height (m) of wheat as affected by Planting technique and Integrated Nutrient Management.*

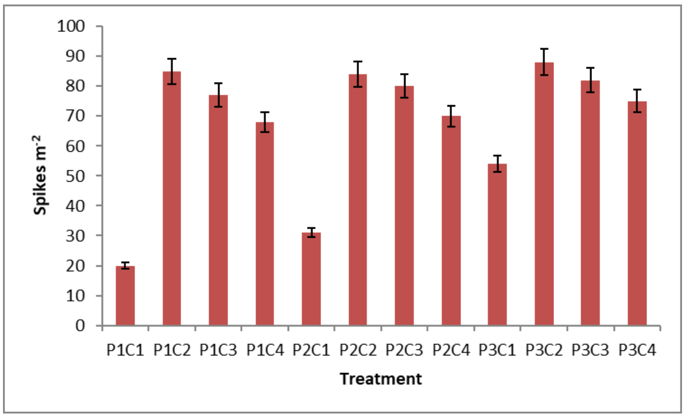

Figure 3: *Spikes (m^{-2}) of wheat as affected by Planting technique and Integrated Nutrient Management.*

In case of integrated nutrient management, no N-fertilizer (control), and compost sole (100%) gave the lowest and highest plant height respectively. The combination of compost (50%) and inorganic fertilizer (50%) showed a better result in terms of plant height than the inorganic fertilizer sole (100%). In overall observations, the application of compost increases the wheat plant height when 20 cm high raised beds adopt. The result is similar to Khurshid *et al.* (2017). They stated that compost has the capacity to enhance the plant height and growth due to the presence of various essential nutrients. The results are further supported by Adeel *et al.* (2019). They documented that compost have the ability to enhance the growth of wheat. Michal (2014) stated that compost provide optimum temperature of soil for crop growth and hence increase plant height.

Spikes m^{-2}

The result showed that the treatments had a significant effect on the spike m^{-2}. The highest spike m^{-2} (88) was recorded in the treatment P3C2 (a combination of 20 cm high raised bed and compost application) while the lowest (20) was found in P1C1 (a combination of flatbed and no-fertilizer) as shown in Figure 3. The recorded highest spike m^{-2} was 85, 84 and 88 in flatbed (control), 10 cm high raised bed and 20 cm high raised bed respectively in the application of compost (100%) to fulfill the nitrogen requirements. Similarly, the lowest spike m^{-2} found was 20, 31 and 44 in flatbed (control), 10 cm high raised seed bed and 20 cm high raised seed bed respectively in no N-fertilization application. In the case of integrated nutrient management, no N-fertilizer (control) and compost sole (100%) showed the lowest and highest spike m^{-2} respectively. The combination of compost (50%) and inorganic fertilizer (50%) showed better results in terms of spike m^{-2} than the inorganic fertilizer sole (100%). In overall observations, the application of compost increases the wheat spike m^{-2} when 20 cm high raised beds adopt. The results coincide to the Shahzad *et al.* (2019), they stated that plant per meter square is significantly affected by the planting techniques. Kahsif *et al.* (2018) documented the same results that the raised bed are much better than the flat seed bed for producing high number of plants per meter square. These results are comparable to the Majeed *et al.* (2015), they concluded that optimum nitrogen application showed better results in the raised bed planting technique than flatbed in terms of spike m^{-2}. Khurshid *et al.* (2017) stated that compost enhances spike m^{-2}. Raman *et al.* (2018) proved that the combination of urea and organic manure is the optimum option for growth of crops.

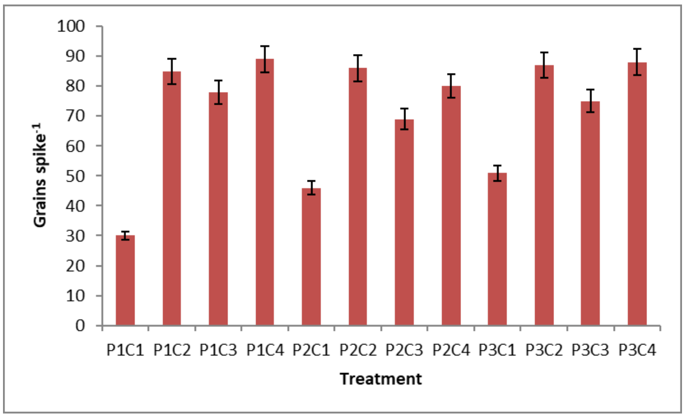

Figure 4: *Grains (spike^{-1}) of wheat as affected by Planting technique and Integrated Nutrient Management.*

Grains spike^{-1}

The result showed that the treatments had a significant effect on the plant height. The highest grain spike^{-1} (89) was recorded in the treatment P1C4 (a combination of flatbed and inorganic fertilizer application) while the lowest (30) was found in P1C1 (a combination of flatbed and no-fertilizer) as shown in Figure 4. The recorded highest grain spike^{-1} was 89, 86 and 88 in flatbed (control), 10 cm high raised bed and 20 cm high raised bed respectively. The flatbed and 20 cm high raised bed showed higher grain spike^{-1} when inorganic fertilizer applied but in 10 cm high raised bed the highest grain spike^{-1} was found in compost (100%) applied plots. Similarly, the lowest grain spike^{-1} found was 30, 46, and 51 in flatbeds (control), 10 cm high raised seed bed and 20 cm high raised bed respectively in a no N-fertilizer application. Shah *et al*. (2016) found that increasing the height of furrow decline the grain spike^{-1} due to a shortage of water in the root zone of a crop. Therefore, it is necessary to adopt the planting technique which provides an optimum level of water to the root zone. Same results were found by Singh and Singh (2019). They stated that planting method significantly affected the number of grains per plant. Raised seed bed showed better results than the flat seed bed and ridges. In the case of integrated nutrient management, no N-fertilizer (control) led lowest while compost sole (100%) and inorganic fertilizer (100%) showed the highest grain spike^{-1}. The compost sole (100%) and inorganic fertilizer sole (100%) showed better result in terms of grain spike^{-1} than the other fertilization treatments. In overall observations, application of compost sole and inorganic fertilizer increased the wheat grain spike^{-1} when flat bed or 10 cm high raised beds adopt. Amanullah *et al*. (2015) result that inorganic fertilizer and compost sole enhance the grain spike^{-1} in flatbed sowing. Same results were delivered by Adeel *et al*. (2019). They stated that combination of urea and compost manure may produce better quality and quantity of crop. Majeed *et al*. (2015) concluded that the increase in the height of the raised bed from 15 cm decrease the water and nutrient use efficiency as a result grain spike^{-1} and grain yield may decrease.

Thousand grain weight (g)

The result showed that the treatments had a significant effect on the thousand-grain weight (g). The highest thousand-grain weight (45 g) was recorded in the treatment P1C4 (a combination of flatbed and inorganic fertilizer application) and P3C4 (a combination of 20 cm high raised bed and inorganic fertilizer application) while the lowest (38.6 g) was found in P3C1 (a combination of 20 cm high raised bed and no-fertilizer) as shown in Figure 5. The recorded highest plant height was 45 g, 44.3 g, and 45 g in flatbed (control), 10 cm high raised bed, and 20 cm high raised bed respectively. In 10 cm high raised bed the highest thousand-grain weight was recorded in the combination of compost (100%) application while in flatbed and 20 cm high raised bed, it is found in inorganic fertilizer (100%). Similarly, the lowest thousand-grain weight found was 39.8, 38.8, and 38.6 flatbeds (control), 10 cm high raised bed, and 20 cm high raised bed respectively. The result coincides with Li *et al*. (2010). They concluded that the highest thousand-grain weight is achieved at flatbed adoption but may be enhanced when the raised bed increase above 15 cm. The result is further supported by Kashif *et al*. (2018). In the case of integrated nutrient management, no N-fertilizer (control) showed the lowest while the compost sole and combination of compost with inorganic fertilizer gave the highest thousand-grain weight. The same results were found by Amanullah *et al*. (2015) that compost application increases the thousand-grain weight. Michal (2014) stated that compost provide optimum soil environment for nutrients to ionize and to make nitrogen pool. Thus, compost enhances the weight of grains by providing more nutrients to the crop. In overall observations, the application of compost increases the wheat thousand-grain weight when flat or 20 cm high raised beds adopt.

Biological yield (kg ha^{-1})

The highest (9144 kg ha^{-1}) and lowest biological yield (6502 kg ha^{-1}) was recorded in the combination of P1 (flatbed) with C3 (compost + inorganic fertilizer) and combination of P3 (20 cm high raised bed) with C1 (no-fertilizer) respectively. The result showed that the treatments had a significant effect on the biological yield as shown in Figure 6. The recorded highest biological yield was 9144 kg ha^{-1}, 8740 kg ha^{-1}, and 8266 in flatbed (control), 10 cm high raised bed, and 20 cm high raised bed respectively in the application of compost (50%) + inorganic fertilizer (50%) or inorganic fertilizer (100%) sole to fulfill the nitrogen requirements. Majeed *et al.* (2015) recorded that the highest biological yield achieved in adopting the flatbed sowing technique. In the case of wheat production, modification in flatbed reduces the biological yield. Singh and Singh (2019) stated that flat seed bed has a shortcoming for producing optimum biological yield. Similarly, the lowest biological yield found was 6844 kg ha^{-1}, 6515 kg ha^{-1} and 6502 kg ha^{-1} in flatbed (control), 10 cm high raised bed and 20 cm high raised bed respectively in no-fertilization application. In the case of integrated nutrient management, no N-fertilizer (control) showed the lowest biological yield. Inal *et al.* (2015) showed the same result. They concluded that inorganic fertilizer and organic fertilizer both increase the biological yield in their combination form as well as individually. Amanullah *et al.* (2015) result that inorganic fertilizer and compost sole enhance the biological yield. Same results were delivered by Adeel *et al.* (2019). They stated that combination of urea and compost manure individually produced high quantity of dried biomass crop. The inorganic fertilizer sole (100%) and the combination of compost (50%) with inorganic fertilizer (50%) showed better results in terms of biological yield than the other treatments.

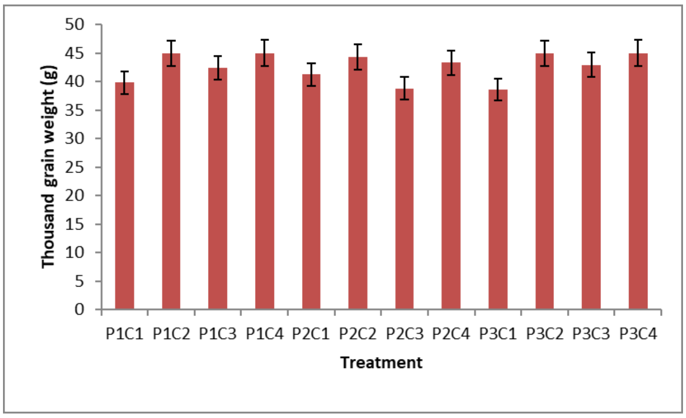

Figure 5: *Thousand grain weight (g) of wheat as affected by Planting technique and Integrated Nutrient Management.*

Grain yield (kg ha^{-1})

The result showed that the treatments had a significant effect on the grain yield. The highest grain yield (3298 kg ha^{-1}) was recorded in the treatment P2C3 (a combination of 10 cm high raised bed and compost + inorganic fertilization) followed by 3274 kg ha^{-1} in P3C4 (20 cm high raised seed bed and inorganic fertilizer sole) and 3259 kg ha^{-1} in P2C2 (10 cm high raised seed bed and compost sole) while the lowest (2030 kg ha^{-1}) was found in P1C1 (a combination of flatbed and no-fertilizer) followed by 2120 kg ha^{-1} in P2C1 (10 cm high raised seed bed and no fertilizer) as shown in Figure 7. The results do not match with Majeed *et al.* (2015). It's May due to the high pH of the soil. Because of increasing soil pH, the grain yield, and harvest index decreased (Gentili *et al.*, 2018).

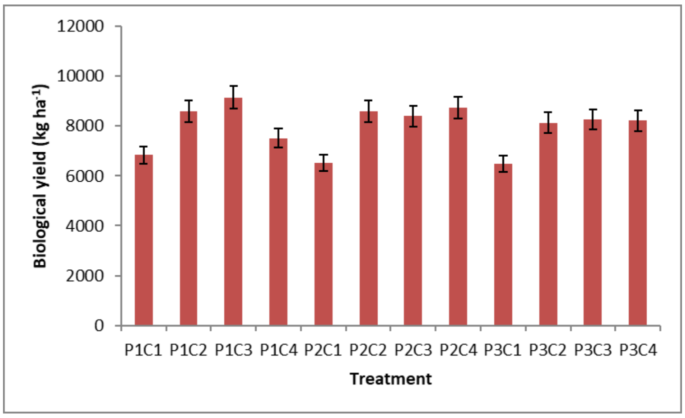

Figure 6: *Biological yield (kg ha^{-1}) of wheat as affected by Planting technique and Integrated Nutrient Management.*

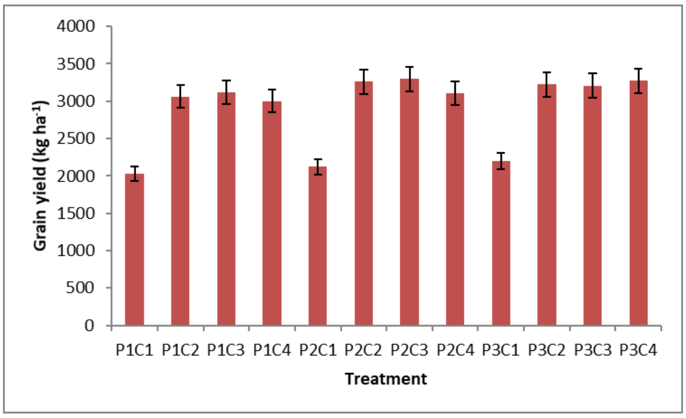

Figure 7: *Grain yield (kg ha^{-1}) of wheat as affected by Planting technique and Integrated Nutrient Management.*

In the case of integrated nutrient management, compost sole (100%) and combination of compost (50%) with inorganic fertilizer (50%) showed higher grain yield. Inal *et al.* (2015) showed the same results. Khurshid *et al.* (2017) stated that compost is rich in nutrients. These nutrients release to the crop root gradually and thus provide more nutrients in grain producing stage of wheat. As a result grain yield increased. Raman *et al.* (2018) proved that the combination of urea and organic manure increase the grain yield well than the urea sole application. In overall observations, the application of compost (50%) + inorganic fertilizer (50%) increases the wheat grain yield.

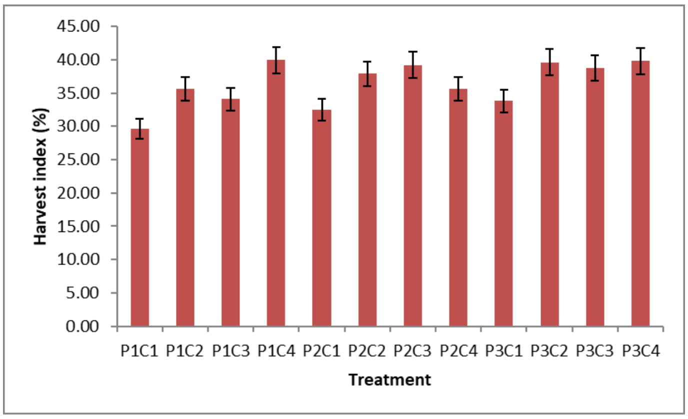

Figure 8: *Harvest index (%) of wheat as affected by Planting technique and Integrated Nutrient Management.*

Harvest Index (%)

The highest (39.91%) harvest index was found in P1C4 (flat seed bed with inorganic fertilizer) followed by 39.83%, 39.59% and 39.23% in P3C4 (20 cm high raised seed bed with inorganic fertilizer), P3C2 (20 cm high raised seed bed with compost sole) and P2C3 (10 cm high raised seed bed with compost + inorganic fertilizer) respectively. The lowest (29.67%) harvest index were found in P1C1 (a combination of a flatbed with no N-fertilizer) followed by 32.54% in P2C1 (10 cm high raised seed bed with no fertilizer). The statistical analysis showed that the treatments had a significant effect on the harvest index as shown in Figure 8. Equivalent harvest index (33.79-34.10%) was found in P3C1 (20 cm high raised seed bed with no N-fertilizer) and P1C3 (flat seed bed with compost + inorganic fertilizer). P2C2 (37.88%) and P3C3 (38.78%) had a nearly equal harvest index to highest. The result is similar to Majeed *et al.* (2015). They found that a raised bed is suitable for achieving a high harvest index than the other sowing techniques. Kashif *et al.* (2018) documented that higher harvest index was found in raised seed bed than the flat seed bed. Singh and Singh (2019) stated that as the raised seed bed increase the grain yield of crop therefore it affect harvest index positively. In the case of integrated nutrient management, compost sole (100%) and the combination of compost (50%) with inorganic fertilizer (50%) showed a better result than the other treatments in terms of harvest index (%). The result coincides with Li *et al.* (2015) and Amanullah *et al.* (2015). The results are further supported by Khurshid *et al.* (2017). They stated that compost enhances harvest index of a crop by increasing its grain yield. Raman *et al.* (2018) concluded that the combination of urea and organic manure gave highest harvest index of wheat than the urea sole and organic manure sole. These nutrients increase the grain yield of wheat therefore the harvest index jump to peak rather than the same effect with other treatments. In overall observations, the application of compost sole and compost (50%) + inorganic fertilizer (50%) increases the wheat plant height.

Conclusions and Recommendations

The experiment was performed to study the effect of planting techniques and integrated nutrient management on the wheat. The result showed that the treatments had a significant effect on the wheat parameters. Among the planting techniques 20 cm high raised seed bed showed better results than the 10 cm high raised bed and flat seed bed in most of the parameters. On the other hand, compost sole and combination of compost with inorganic fertilizer achieved higher value than the inorganic fertilizer sole and control. The research should be repeated with other soil factors for enhancing the yield of wheat.

Novelty Statement

Increasing yield of wheat, raised seed bed is used in developed countries. The dimension of the raised seed bed is not been specified for optimum yield of wheat. Therefore, the optimum dimension of raised seed bed should be found.

Authors' Contribution

Inam Ul Haq: Conducted research, data collection, analysis and wrote draft of the manuscript.
Muhammad Ramzan: Supervised and designed the research.
Mansoor Khan Khattak: Co-supervised the research, helped data collection,
Ahmad Khan: Provided technical guidelines and editing of the manuscript.

Conflict of interest

The authors declared that there is no conflict of interest among the authors of the manuscript.

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