Adaptation of Agricultural Practices Toward Mitigating Drought Effects on Wheat (*Triticum aestivum* L.) Production in Palestine

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This thesis is submitted in partial fulfillment of the requirements for the degree of Master of Science in Natural Resources and its Sustainable Management, College of Graduate Studies, Hebron University, Palestine.

June 2021
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Main Supervisor
External examiner
Internal examiner

Signature
DEDICATION

I would like to dedicate this thesis to:

   My great Mother

   The memory of my Father

   My dear wife

   My sweet daughter Elana

   My awesome sons Jaber and Abdur-Rahman

   My lovely sister and brothers.
ACKNOWLEDGMENT

At the outset and in closing all thanks to Allah who guide me and help me in the whole of my life.

Then I would like to express my heartfelt appreciation and gratitude to my supervisor and role model Prof. Dr. Rezq Basheer-Salimia for his devoted supervision, orientation and guidance.

Also, with all my heart I would like to thank my great mother whose sacrifice made me the person who I am now and who will be tomorrow. Additionally, I would like to thank my wife and my children for their patience and understanding. Without the fabulous support and encouragement that I got from my family in the past few years, it would not be possible for me to step forward.

I also thank all of my friends and colleagues (Abdur-Razeq Mohsen, Dr. Mohammad Al-Salimya, Hisham Ayyad, Mohammad Al-Amleh, Thaer Arqub and Hamza Brejeya) for their inspiration and consolidation.

Moreover, I gratefully thank the Palestinian Agricultural Academic Cooperation (PAAC; NICHE-PAA, 233, project, NUFFIC, the Netherlands) for their partially financial support of this study.

Finally, my gratitude extends to Hebron university that embrace a complementary competency and well-equipped facilities that provide the students a comfortable condition for education and innovation.

For all of you … my thanks and gratitude.

Eyaas Abu-Rabada.
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General abstract

Wheat (*Triticum aestivum* L.) is considered the main aspect of the world food security including the Middle-East. Indeed, demand on wheat increases from year to year and from country to country. Although, the general world wheat production increased, there were relapses in some countries due to many reasons like drought, bad rainfall distribution, above average temperatures, edaphic factors, locust attach and human conflicts. In Palestine, this important crop testifies sharp decline in its productivity due to many reasons including bad agricultural practices, deterioration of the crop varieties, biotic stress, climate change effects and its consequences in particular. Indeed, drought and heat are the main agricultural constraints that reduce crop productivity in the Middle-East in general including Palestine with no exception. However, many approaches have been introduced to mitigate the impact of climate change and to increase wheat productivity including agronomic practices manipulation such as tillage and fertilization which found to be the most applicable practices due to ease of application, low cost and ability to be implemented and/or examined not only by scientists but also by farmers, whom originally manipulated, modified and adopted the agronomic practices over the human history.

This study was conducted during the growing season of 2018/2019 at the eastern slopes of Bethlehem governorate that are influenced by drought and classified as arid to semi-arid areas. The main goal of this study is to evaluate the impact of different tillage and fertilization practices on morphological features and yield components of winter wheat (var. Yellow Heteya), which grown under rain-fed conditions.

In the first experiment, four tillage systems including conventional tillage (CT) and three conservation tillage systems (reduced tillage (RT), conservation tillage at 8cm (C8) and conservation tillage at 4cm depth (C4)) were investigated in a randomized complete block design (RCBD) with 3 replicates. In addition, a second trial was laid out in a factorial randomized block design, where the tillage practices combined with different fertilization types comprising sheep manure (M), tri-superphosphate (TSP) and ammonium sulfate (AS), in which they all coupled with different fertilizers ratios as the following (manure 6m³/dunum (M$_{6m^3}$); manure 3m³/dunum+ TSP 6.25 kg/dunum+ AS 6.25 kg/dunum (M$_{3m^3}$/TSP$_{6.25kg}$/AS$_{6.25kg}$); manure 3m³/dunum+ TSP 12.5 kg/dunum (M$_{3m^3}$/TSP$_{12.5kg}$) and manure 3m³/dunum+ AS 12.5 kg/dunum (M$_{3m^3}$/AS$_{12.5kg}$).
Significant differences among the examined parameters were observed. Overall the examined tillage types and sowing depths, the reduced tillage system presented significant higher yield, stem length, and spike parameters values followed by the conventional system. Also, in the second trial of the study, our results revealed the superiority of the RT\times M_{6m}^3 in term of grain yield production and RT\times M_{3m}^3/TSP_{12.5kg} in term of straw production. Moreover, the reduced tillage system dominates the other tillage treatments in the morphological characteristics that considered an important indicator for the response of plants to the tested treatments and their adaptation to the stress conditions. Furthermore, in the two studies both of 4 and 8 cm tillage types exhibited the lowest values even when they were combined with fertilizers. Keeping in mind that in some parameters the CT revealed slightly higher production values, but these values are not higher enough to cover the financial expenditures of tillage frequency treatment. Regarding the fertilization treatments, M_{6m}^3 in general revealed the highest production and morphological values comparing to the other fertilization treatments. Significantly lowest values presented in the conservation systems might be explained by its initial stage of transformation to the conservation system which commonly needs many years. Indeed, for the aims of conservation agriculture about 30% of plant residue must be remains in the land, but due to rangeland area decline that related to the climatic change, urban sprawl and Israeli restriction, the farmers became forced for shepherding their flocks in the field harvest leftovers. For that it is highly recommended to aware the herders about the advantages of keeping the plants residues in the land that leads to increase the productivity.

This short term study is definitely not sufficient to reveal the impact of the examined tillage and fertilization practices, but it gives indicators for a promising practices to cope with the climate change effect that need more investigation on longer term.

**Keywords:** conservation tillage, drought, reduced tillage, organic fertilizers, Palestine, Wheat (*Triticum aestivum* L.).
CHAPTER I: Literature Review

1.1. Wheat:

1.1.1. Wheat origin:

Wheat (\textit{Triticum aestivum} L.) is one of the oldest plants that initially domesticated by humanity. It is hypothesized that wheat was originated in the Fertile Crescent (Uthayakumaran and Wrigley, 2017). Palestine as part of the Fertile Crescent is known for thousands of years as one of the first civilizations that develop the humanity lifestyle and transform the human from hunting to farming and animal domestication (Elazari-Volcani, 1925), in parallel agricultural practices have been developed along the progress of humanity (Igrejas and Branlard, 2020). The Natofian culture that have arisen in Palestine about 13000 B.P. was the pioneer of humanity development and sedentism, where the anthropological evidences showed that Natofians firstly domesticated wheat, barley and other cereals for the aims of food and fodder production (Ofer, 1998). Later on, it was suggested that wheat spread to Asia, Europe and Africa around 4000 BC (Uthayakumaran and Wrigley, 2017). Yet, there is still wide argument within the scientific communities about the genetic origin and the taxonomy of (\textit{Triticum aestivum} ssp. aestivum) (Bálint \textit{et al.}, 2000; Goncharov \textit{et al.}, 2009).

1.1.2. Wheat taxonomy:

As shown in table (1.1), wheat is a C3 herbaceous plant that belonging to the genus Triticum, in which a broad spectrum of species is involved, however the most common species among them are \textit{Triticum aestivum} L. which are commonly used for bread and Triticum durum that commonly used for spaghetti, pasta and macaroni (Uthayakumaran and Wrigley, 2017).

\begin{table}[h]
\centering
\begin{tabular}{|c|c|}
\hline
\textbf{Kingdom} & \textbf{Plantae –plants, Planta, Vegetal, plants} \\
\hline
\textbf{Subkingdom} & \textbf{Viridia...}
\end{tabular}
\end{table}

\textit{Table 1.1. Wheat taxonomic hierarchy. http://plants.usda.gov
According to Dvořák (2001) and Uthayakumaran and Wrigley, (2017), naturally Triticum can be classified according to their chromosomes number as the following:

1. **Diploides** (2n = 14); which include the wild wheat (*T. uratu*) and cultivated kind (*T. monococcum* L.),

2. **Tetraploids** (2n = 28); which include the cultivated wheat (*T. turgidum*) and the wild one (*T. timopheevii*), that considered the preliminary step towards the Hexaploide wheat, where it resulted from the natural hybridization between *T. urartu* and *Aegilops*,

3. **Hexaploides** (2n = 42); e.g. *T. aestivum*, which was naturally hybridized by *T. dicoccoides* with *T. tauschii*, this level has no wild progenitor and considered the most important wheat due to its use in bread, and

4. **Octaploid** (2n = 56); Goncharov (2011) highlighted the artificially hybridized Octaploid species that is still studied in the laboratories, which is resulted from the hybridization of *Ae. geniculata* and polyploids wheat.

In fact, a wider classification for wheat is also exist which depends mainly on ploidy levels, cytoplasm types, and genome compositions (Goncharov, 2011). In addition, more specified classification at the species level is also exist, in which *T. aestivum* could be classified according to seed coat pigment (red and white), resistance to crush (soft and hard) and growing season (winter and spring) (Gooding 2009; Uthayakumaran and Wrigley, 2017)

1.1.3. Economical importance:

The importance of wheat is not only raised from being human food, it is also used as animal fodder. In addition, the gluten and wheat starch are used in many industries such as food additives, baby foods, cosmetics, etc. (Igrejas and Branlard, 2020). Based on
FAO statistics, demand on wheat increases from year to year and from country to country. In 2019, the world wheat production was about 763.6 million ton, which is 4.2% higher than 2018 and expected to be unchanged in 2020 (FAO, 2020). Although, the general world wheat production increased in the past decade, there were declines in some countries due to many reasons like shortage of rain, bad rainfall distribution, above average temperatures, edaphic factors, locust and human conflicts (FAO, 2020).

1.1.4. Wheat production and distribution:

During the past two centuries, wheat has reached almost around the world, wherever the environmental conditions are suitable. By screening 105 countries it was found that 4506 wheat races -of which 632 are bread wheat- were widely divers and hybridized and resulted modern cultivars that are more adaptable and tolerable to the extreme biotic and abiotic stress (Balfourier et al., 2019). Comparably, China is ranked first in wheat production (132,518,400 ton) followed by India (101,732,875 ton), Russia (73,294,421 ton) and USA (51,781,580 ton) (FAOSTAT, 2020). For Palestine, statistics of 2018 showed that we produced only about 23773 ton from 133475 dunum (Palestinian Ministry of Agriculture, 2018).

1.1.5. Environmental requirements:

*Triticum aestivum* L. is grown in wide range of environmental conditions all around the world; however, the growing requirements are varied according to the cultivar and the developmental stage. Wheat can be grown in arid, semi-arid and humid zones, in a wide average rainfall range. The optimum temperature for wheat development is ranged from 15-23°C, but temperature above 34°C during the grain filling stage could reduce the grain yield. Additionally, wheat can be grown in varied range of soils that may affect wheat performance according to their depth, texture, fertility and other biological and physiochemical characteristics (Asseng et al., 2012).

1.1.6. Life cycle:

The life cycle of wheat is commonly last for 140 – 180 days after planting and it is influenced by many factors including wheat genotype, growing season, environmental conditions and different biotic and abiotic stress. However, the complete life cycle of wheat includes ten developmental stages that started from seeds germination that leads to seedling emergence and growth, followed by tillering, stem elongation, booting, ear
emergence, flowering, milk development, dough development and finally the ripening (Fowler, 2018).

Table 1.2. Common wheat growth and developmental stages and their codes according to Zadoks et al. (1974).

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Germination</td>
<td>37</td>
<td>Flag leaf just visible</td>
</tr>
<tr>
<td>0.0</td>
<td>Dry seed</td>
<td>38</td>
<td>Flag leaf just visible</td>
</tr>
<tr>
<td>0.1</td>
<td>Start of imbibition</td>
<td>0.2</td>
<td>Imbibition complete</td>
</tr>
<tr>
<td>0.3</td>
<td>Radical emerged from seed</td>
<td>0.4</td>
<td>Coleopyle emerged from seed</td>
</tr>
<tr>
<td>0.5</td>
<td>Leaf just at coleopyle tip</td>
<td>4.0</td>
<td>Booting</td>
</tr>
<tr>
<td>1.0</td>
<td>Seedling growth</td>
<td>41</td>
<td>Flag leaf sheath extending</td>
</tr>
<tr>
<td>1.1</td>
<td>First leaf through coleopyle</td>
<td>43</td>
<td>Boots just visible swollen</td>
</tr>
<tr>
<td>1.2</td>
<td>First leaf unfolded</td>
<td>44</td>
<td>Boots swollen</td>
</tr>
<tr>
<td>1.3</td>
<td>2 leaf unfolded</td>
<td>45</td>
<td>Boots swell</td>
</tr>
<tr>
<td>1.4</td>
<td>4 leaf unfolded</td>
<td>4.6</td>
<td>Ear emergence</td>
</tr>
<tr>
<td>1.5</td>
<td>5 leaf unfolded</td>
<td>51</td>
<td>First spikelet of ear just visible</td>
</tr>
<tr>
<td>1.6</td>
<td>6 leaf unfolded</td>
<td>53</td>
<td>One-fourth of ear visible</td>
</tr>
<tr>
<td>1.7</td>
<td>7 leaf unfolded</td>
<td>55</td>
<td>One-half of ear emerged</td>
</tr>
<tr>
<td>1.8</td>
<td>8 leaf unfolded</td>
<td>57</td>
<td>Three-fourths of ear emerged</td>
</tr>
<tr>
<td>1.9</td>
<td>9 or more unfolded</td>
<td>59</td>
<td>Emergence of ear completed</td>
</tr>
<tr>
<td>2.0</td>
<td>Tillering</td>
<td>6.0</td>
<td>Flowering</td>
</tr>
<tr>
<td>2.1</td>
<td>Main shoot only</td>
<td>51</td>
<td>Beginning of flowering</td>
</tr>
<tr>
<td>2.2</td>
<td>Main shoot and 1 tiller</td>
<td>65</td>
<td>Flowering half-way complete</td>
</tr>
<tr>
<td>2.3</td>
<td>Main shoot and 2 tillers</td>
<td>90</td>
<td>Flowering complete</td>
</tr>
<tr>
<td>2.4</td>
<td>Main shoot and 3 tillers</td>
<td>7.0</td>
<td>Milk development</td>
</tr>
<tr>
<td>2.5</td>
<td>Main shoot and 4 tillers</td>
<td>71</td>
<td>Sack yellow</td>
</tr>
<tr>
<td>2.6</td>
<td>Main shoot and 5 tillers</td>
<td>73</td>
<td>Early milk</td>
</tr>
<tr>
<td>2.7</td>
<td>Main shoot and 6 tillers</td>
<td>75</td>
<td>Medium milk</td>
</tr>
<tr>
<td>2.8</td>
<td>Main shoot and 7 tillers</td>
<td>77</td>
<td>Late milk</td>
</tr>
<tr>
<td>2.9</td>
<td>Main shoot and 8 or more tillers</td>
<td>83</td>
<td>Dough development</td>
</tr>
<tr>
<td>3.0</td>
<td>Stem elongation</td>
<td>85</td>
<td>Early dough</td>
</tr>
<tr>
<td>3.1</td>
<td>1st node detectable</td>
<td>87</td>
<td>Hard dough</td>
</tr>
<tr>
<td>3.2</td>
<td>2nd node detectable</td>
<td>89</td>
<td>Head losing stipphyphist</td>
</tr>
<tr>
<td>3.3</td>
<td>3rd node detectable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4</td>
<td>4th node detectable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>5th node detectable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6</td>
<td>6th node detectable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.7</td>
<td>Flag leaf just visible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.8</td>
<td>Flag leaf just visible</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.1.7. Yield and morphological performance:

Many wheat parameters including yield and morphological traits have been studied and evaluated for different wheat varieties. These parameters are genetically controlled and affected by different biotic and abiotic stresses. In addition, they are correlated to each other in different ways and may affect directly or indirectly wheat performance and behavior (Farooq et al., 2018; Tshikunde et al., 2019).
Table 1.3. Collection of evaluated wheat yield components, morphological traits and some physiological variables.

<table>
<thead>
<tr>
<th>#</th>
<th>Parameters</th>
<th>References</th>
<th>#</th>
<th>Parameters</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total yield</td>
<td>Thirkei et al., 2019</td>
<td>12</td>
<td>Spike Fertility</td>
<td>Tshikunde et al., 2019</td>
</tr>
<tr>
<td>2</td>
<td>Grain yield</td>
<td>Zhang et al., 2020</td>
<td>13</td>
<td>Spike compactness</td>
<td>Tshikunde et al., 2019</td>
</tr>
<tr>
<td>3</td>
<td>Grain weight / plant</td>
<td>Farooq et al., 2018</td>
<td>14</td>
<td>Number of spikes / m²</td>
<td>Beral et al., 2020</td>
</tr>
<tr>
<td>4</td>
<td>Straw yield</td>
<td>Zhang et al., 2020</td>
<td>15</td>
<td>Number of grains / spikes</td>
<td>Khorami et al., 2018</td>
</tr>
<tr>
<td>5</td>
<td>Harvest index</td>
<td>Panozzo et al., 2020</td>
<td>16</td>
<td>Grain weight / spike</td>
<td>Ashfaq et al., 2003</td>
</tr>
<tr>
<td>6</td>
<td>Plant height</td>
<td>Jiang et al., 2020</td>
<td>17</td>
<td>Number of kernels / spikelet's</td>
<td>Würschum et al., 2018</td>
</tr>
<tr>
<td>7</td>
<td>awn shape and length</td>
<td>Yoshioka et al., 2017</td>
<td>18</td>
<td>Number of spikes / plants</td>
<td>Panozzo et al., 2020</td>
</tr>
<tr>
<td>8</td>
<td>Spike length</td>
<td>Boussakouran et al., 2019</td>
<td>19</td>
<td>Number of spikelets / spikes</td>
<td>Djuric et al., 2018</td>
</tr>
<tr>
<td>9</td>
<td>Spike size</td>
<td>Panozzo et al., 2020</td>
<td>20</td>
<td>spikelet arrangement</td>
<td>Wolde et al., 2019</td>
</tr>
<tr>
<td>10</td>
<td>Spike weight</td>
<td>Chen et al., 2019</td>
<td>21</td>
<td>Wight of 1000 grain</td>
<td>Gholami et al, (2014)</td>
</tr>
<tr>
<td>11</td>
<td>Spike area</td>
<td>Boussakouran et al., 2019</td>
<td>22</td>
<td>Grain size</td>
<td>Beral et al., 2020</td>
</tr>
<tr>
<td>12</td>
<td>Spike Fertility</td>
<td>Tshikunde et al., 2019</td>
<td>23</td>
<td>Grain shape</td>
<td>Nuttall et al., 2017</td>
</tr>
<tr>
<td>13</td>
<td>Spike compactness</td>
<td>Tshikunde et al., 2019</td>
<td>24</td>
<td>Grain hardness</td>
<td>Nuttall et al., 2017</td>
</tr>
<tr>
<td>14</td>
<td>Number of spikes / m²</td>
<td>Beral et al., 2020</td>
<td>25</td>
<td>Grain N content</td>
<td>Nuttall et al., 2017</td>
</tr>
<tr>
<td>15</td>
<td>Number of grains / spikes</td>
<td>Khorami et al., 2018</td>
<td>26</td>
<td>Grain starch content</td>
<td>Nuttall et al., 2017</td>
</tr>
<tr>
<td>16</td>
<td>Grain weight / spike</td>
<td>Ashfaq et al., 2003</td>
<td>27</td>
<td>Milling yield</td>
<td>Nuttall et al., 2017</td>
</tr>
<tr>
<td>17</td>
<td>Number of kernels / spikelet's</td>
<td>Würschum et al., 2018</td>
<td>28</td>
<td>Number of grains / m²</td>
<td>Beral et al., 2020</td>
</tr>
<tr>
<td>18</td>
<td>Number of spikes / plants</td>
<td>Panozzo et al., 2020</td>
<td>29</td>
<td>Flag leaf length</td>
<td>Boussakouran et al., 2019</td>
</tr>
<tr>
<td>19</td>
<td>Number of spikelets / spikes</td>
<td>Djuric et al., 2018</td>
<td>30</td>
<td>Flag leaf width</td>
<td>Tshikunde et al., 2019</td>
</tr>
<tr>
<td>20</td>
<td>spikelet arrangement</td>
<td>Wolde et al., 2019</td>
<td>31</td>
<td>Flag leaf area</td>
<td>Boussakouran et al., 2019</td>
</tr>
<tr>
<td>21</td>
<td>Wight of 1000 grain</td>
<td>Gholami et al, (2014)</td>
<td>32</td>
<td>Flag leaf angle</td>
<td>Tshikunde et al., 2019</td>
</tr>
<tr>
<td>22</td>
<td>Grain size</td>
<td>Beral et al., 2020</td>
<td>33</td>
<td>Green leaf area</td>
<td>Boussakouran et al., 2019</td>
</tr>
<tr>
<td>23</td>
<td>Grain shape</td>
<td>Nuttall et al., 2017</td>
<td>34</td>
<td>Leaf area</td>
<td>Ajlouni et al., 2020</td>
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<tr>
<td>24</td>
<td>Grain hardness</td>
<td>Nuttall et al., 2017</td>
<td>35</td>
<td>Leaf hairiness</td>
<td>Doroshkov et al., 2011</td>
</tr>
<tr>
<td>25</td>
<td>Grain N content</td>
<td>Nuttall et al., 2017</td>
<td>36</td>
<td>Trichome number and length</td>
<td>Pshenichnikova et al., 2016</td>
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<td>26</td>
<td>Grain starch content</td>
<td>Nuttall et al., 2017</td>
<td>37</td>
<td>Leaf dry weight</td>
<td>Ajlouni et al., 2020</td>
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<td>27</td>
<td>Milling yield</td>
<td>Nuttall et al., 2017</td>
<td>38</td>
<td>Stem length</td>
<td>Kayan et al., 2018</td>
</tr>
<tr>
<td>28</td>
<td>Number of grains / m²</td>
<td>Beral et al., 2020</td>
<td>39</td>
<td>Stem strength</td>
<td>Karman et al., 2018</td>
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<td>Flag leaf length</td>
<td>Boussakouran et al., 2019</td>
<td>40</td>
<td>peduncle length</td>
<td>Farooq et al., 2018</td>
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<td>Tshikunde et al., 2019</td>
<td>41</td>
<td>Node and internode</td>
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<td>Flag leaf area</td>
<td>Boussakouran et al., 2019</td>
<td>42</td>
<td>Number of shoots</td>
<td>Djuric et al., 2018</td>
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<td>32</td>
<td>Flag leaf angle</td>
<td>Tshikunde et al., 2019</td>
<td>43</td>
<td>Tillers number</td>
<td>Ali et al., 2016</td>
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<td>33</td>
<td>Green leaf area</td>
<td>Boussakouran et al., 2019</td>
<td>44</td>
<td>Tillers fertility</td>
<td>Ye et al., 2015</td>
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<td>45</td>
<td>Root biomass</td>
<td>Zhang et al., 2020</td>
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<td>46</td>
<td>Root length</td>
<td>Chen et al., 2017</td>
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<td>Root density</td>
<td>Wasson et al., 2017</td>
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<td>Root dry weight</td>
<td>Petrarulo et al., 2014</td>
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<td>Root surface area</td>
<td>Petrarulo et al., 2014</td>
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<td>50</td>
<td>Average root diameter</td>
<td>Petrarulo et al., 2014</td>
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<td>51</td>
<td>Root volume</td>
<td>Petrarulo et al., 2014</td>
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<td>52</td>
<td>Number of root tips</td>
<td>Petrarulo et al., 2014</td>
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<td>53</td>
<td>Shoot dry weight</td>
<td>Petrarulo et al., 2014</td>
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<td>54</td>
<td>Canopy Temperature</td>
<td>Tshikunde et al., 2019</td>
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<td>Chlorophyll Content</td>
<td>Tshikunde et al., 2019</td>
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<td>photosynthetic capacity</td>
<td>Tshikunde et al., 2019</td>
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<td>Water soluble carbohydrates</td>
<td>Tshikunde et al., 2019</td>
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<td></td>
<td>58</td>
<td>Days to flowering</td>
<td>Tshikunde et al., 2019</td>
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<td>59</td>
<td>Days to maturity</td>
<td>Tshikunde et al., 2019</td>
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<td>60</td>
<td>Membrane Thermostability</td>
<td>Cossani and Reynolds, 2012</td>
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<td>61</td>
<td>Wax/Glaucous</td>
<td>Cossani and Reynolds, 2012</td>
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<td></td>
<td>62</td>
<td>Respiration</td>
<td>Cossani and Reynolds, 2012</td>
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<td>63</td>
<td>Stay-Green</td>
<td>Cossani and Reynolds, 2012</td>
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<td>64</td>
<td>Rapid Ground Cover and Canopy Structure</td>
<td>Cossani and Reynolds, 2012</td>
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<td>65</td>
<td>Photosynthesis/Photorespiration</td>
<td>Cossani and Reynolds, 2012</td>
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<td>66</td>
<td>Photoprotective Metabolites</td>
<td>Cossani and Reynolds, 2012</td>
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</table>
Among these traits and variables, here some common parameters including yield parameters (total yield, grain yield, straw yield) and morphological parameters (weight of 100 grain, tillering, stem length, spike length and spike length without awns) were chosen to be investigated. Indeed, such examined yield and morphological parameters are commonly used to evaluate the suitability and adaptability of wheat genotypes for different environmental conditions (Basheer-Salimia and Atawne, 2014; Al-Salimia et al., 2018). Moreover, these parameters are positively related to wheat adaptation to drought stress, heat stress, nutrients deficiency, pests and diseases (Khaliq et al, 2008; Banerjee et al., 2015; Boussakouran et al., 2019; Ajlouni et al., 2020). Also, these parameters are used to evaluate the response of wheat to different practices like tillage, fertilization, pests control, seedling rate, seedling date, irrigation ….etc. (Lipiec et al., 2013; Hofmeijer et al., 2019; Singh et al., 2020). Interestingly, understanding these variables will enable the researchers and farmers to adapt and select the best genotypes for sustainable wheat production (Al-Salimia et al., 2018).

1.2. Climate change and wheat:

1.2.1. Definition:

Climate change is defined as the periodic modification of earth’s climate brought about as a result of changes in the atmosphere as well as interactions between the atmosphere and various other geologic, chemical, biological, and geographic factors within the earth system (Jackson, 2021).

1.2.2. Climate change effects and impacts:

Climate change is a worldwide issue that threaten the humanity with malnutrition, thirstiness, diseases and displacement. Also, agriculture with all of its nutritional, industrial and medicinal aspects is highly influenced by climate change that may reduce the productivity of croplands and rangelands (Shukla et al., 2019). Indeed, climate change leads to land degradation, desertification and soil infertility which leads to reduce the lands productivity (Shukla et al., 2019). Meanwhile, climate change impacts such as drought, temperature elevation, CO2 elevation, variations of precipitation patterns and changes of pests and diseases attributes are well documented to reduce the crops yield and quality parameters (Raza et al., 2019).
1.2.2.1. Effects of climate change on wheat:
Climatic change (mainly drought and heat stresses) affects almost all of wheat physiological plant ontogeny including germination, seedling growth, tillering, stem elongation, booting, ear emergence, flowering, milk development, dough development, ripening stages and thus total wheat production (Kumar and Singh, 2014). In regions that categorized as a highly affected with climate change (mainly developing countries including Palestine), wheat considered one of the main aspects of food insecurity, due mainly to the visible reduction in its yield and quality.

1.2.2.1.1. Drought stress:
Drought stress is the most obvious impact of climate change and it is the major limiting factor for crops growth and production. Generally, absence and insufficient or uneven rainfall led to drought stress and reduce the soil water content and thereby reduce crops production (Mar et al., 2018; Imadi et al., 2019). Wheat could be highly influenced by drought stress during all of its life cycle, but it is influenced the most in the reproductive phase and grain filling phase, where the grain yield could be reduced up to 92% (Raza et al., 2019). Indeed, drought causes serious lose in wheat grain yield and characteristics due to its negative impact on pollination and photosynthesis. Moreover, it disturbs the physiological functions and genetic expression that inhibit wheat development (Zulfqar et al., 2016).

1.2.2.1.2. Heat stress:
Generally, high temperature causes failure grain filling, florets abortion, leaf senescence, pollen sterility and many other grains qualitative parameters and cause reduction and variation in grain number, size and weight (Zulfqar et al., 2016). Also, temperature stress has a negative impact on wheat grain qualitative parameters, where the crops accelerate its development due to the high temperature (above 30 °C), that limits the grain filling. Also, high temperature reduces the starch accumulation rate in wheat grains, while protein accumulates is unaffected, which resulted higher protein content and consequently alters the functional characteristics of proteins and starches and lead to weak dough structure and properties (Nuttall et al., 2017).

1.2.3. Future scenarios for climate change:
It is expected that during the 21st century the earth's temperature will increase from 2-4.5 °C and that the drought and heat effects will be more dangerous on the ecosystems,
consequently extreme environmental conditions (e.g. extreme precipitation, storms, pests, diseases, high temperature, floods… etc.) will disturb the relations between humans and the components of their environment and will threaten most of the humanity with food insecurity (Raza et al., 2019). Related to wheat production, it is expected that due to extreme drought and heat conditions that the yield production will reduce up to 71%. Also, the severity of some wheat diseases will increase, where it was found that CO$_2$ elevation accelerate the stem rust development. On the other hand, CO$_2$ elevation increases the wheat production due to the fact that it is C3 plant and it responses positively to the CO$_2$ concentration (Zulfqar et al., 2016). Keeping in mind that C3 plants are more affected by high temperature than C4 and conversely in relation to drought (Lipiec et al., 2013).

1.2.4. Climate change in Palestine:

Climate changes have affected Palestine and its impact has been appearing clearly at different levels. However, the annual temperature increased by 0.8°C after 1990 (Abu Hammad and Salameh, 2018) and the rainfall decreased significantly during the past four decades (Albaba, 2017). Moreover, the precipitation pattern has been turned to erratic and uneven especially in the southern and eastern parts of Palestine (Basheer-Salimia and Ward, 2014). This indeed reduced the crops production including wheat (Albaba, 2017), led to land degradation, decreasing soil infertility (Yihdego et al., 2019) and negatively influenced the water resources quality and quantity (Abu Hammad and Salameh, 2018).

1.2.5. Coping with climate changes:

Many approaches have been practiced in order to cope with climate change or to mitigate its effects on agriculture (Nezhadahmadi et al., 2014). These approaches involve genetic engineering (Yadavq and Mishra, 2020), identifying the physiological, biochemical, morphological and molecular stress tolerance mechanisms (Nezhadahmadi et al., 2014). Moreover, breeding (Tadesse et al., 2018) and using of drought-tolerant varieties (Al-salimiyia, et al., 2018) which are qualifies as deep rooted, able to present adaptable morphological characteristics, high yield and water use efficiency (Nezhadahmadi et al., 2014). Furthermore, managing the drought by agronomic practices such as irrigation, fertilization, sowing, crop rotation and crop residue management (Nezhadahmadi et al., 2014; Hatfield and Dold, 2018; Kumar et al, 2019). Another promising and applicable approach is soil management practices to improve
soil physical, chemical and biological properties that include tillage systems and mulching that lead to higher yield (Lipiec et al., 2013).

1.3. Tillage practices:

1.3.1. Tillage importance and effects:

Tillage is a very important practice for soil and water conservation, incorporation of soil amendments (Mohammadshirazi et al., 2017), seed bed preparation (Shahzad et al., 2016), control of soil borne pathogens and pests (Stirling et al., 2012), weeds control (Workayehu, 2010), and creating firebreaks to avoid the hazards of any potential fires (Dzerefos et al., 2016). The effects of tillage could be varied according to the practiced tillage system, soil properties (e.g. texture, depth, slope,…etc.), tillage speed (Raper, 2005), farming system, climate, duration, planted crops (Yagioka et al., 2015), crops residue (Büchi et al., 2018), fertilization (Wyngaard et al., 2012) and tillage tools (Raper, 2005). In particular, tillage affects soil biological, chemical and physical quality parameters and thus influences the crops growth and production (Jonard et al., 2013). Also, tillage affects greenhouse gas emissions (N₂O, CO₂ and CH₄) and nutrients leaching from soil (Yagioka et al., 2015).

1.3.2. Tillage types and tools:

Tillage systems are widely varied around the world (Lal et al., 2007) and could be categorized according to the time of implementation like primary and secondary tillage (Askari and Khalifahamzehghasem, 2013); tillage depth such as surface or deep tillage (Soil Science Glossary Term Committee, 2008; Schneider et al., 2017), and tillage equipment such as cultivator, disc plough, mould-board plough (Rao et al., 2018) and manual plough by using traditional tillage tools like wooden plough that pulled by animals (Lal et al., 2007).

According to Reicosky (2015) categorized tillage types in three forms that are commonly practiced including conventional (traditional) system, conservation system, and no- tillage (Figure 1.1).
1.3.2.1. Conventional (traditional) tillage:

In general, any tillage system that inverts the soil and buries crop residues is considered conventional (traditional) tillage in which it is commonly used for weed control and enhances water infiltration and soil aeration (Morugán-Coronado, et al., 2020). However, conventional tillage has many disadvantages that make it not the best choice to cope with climate change especially in the dry areas (Bogunovic et al., 2018). Indeed, when compared to the conservation systems, conventional tillage revealed higher soil bulk density (Gholami et al., 2014), lower aggregate size and stability (Tagar et al., 2020), lower soil moisture (Yagioka et al., 2015), lower enzymatic activities (Malecka et al., 2015), faster soil organic matter decomposition rate (Houben et al., 2018), higher greenhouse gas emissions and nutrients leaching from soil (Yagioka et al., 2015). Consequently, these valuable factors make the soil more subjected for the climatic factors (e.g. rain, wind.... etc.) which lead to soil erosion and deterioration (Morugán-Coronado, et al., 2020), and thereby reduce crops production (Gholami et al., 2014). Nevertheless, some researchers indicated no significant variation between conventional tillage and other conservation tillage systems (Fuentes et al. 2003; Moraru and Rusu,
Gangwar et al., (2012), while Gangwar et al., (2019) found that conventional tillage exceed the conservation tillage in term of grain yield. In other study, Malecka et al., (2015) compared between conventional and conservation tillage (reduced and no tillage) in Albeluvisol soil type and reported lower soil properties in conventional tillage, but the reduced tillage get the highest results in term of yield followed by the conventional and the no tillage system. Moreover, conventional tillage showed lower soil compaction in the surface soil layer compared to the no tillage system, which reduce water infiltration to the silty clay soil (Shahzad et al., 2016).

1.3.2.2. Conservation tillage:

Conservation system reflecting any form of tillage that minimizes the number of tillage’s passes, where soil aggregate disruption is reduced, and a minimum of 30% of the soil surface covered with residues, with the aim to reduce soil erosion (Soil Science Glossary Term Committee, 2008). Indeed, this practice includes a wide range of tillage practices under its umbrella such as no tillage (zero tillage), reduced tillage (minimum tillage), mulch tillage, and strip tillage/zonal tillage (Soil Science Glossary Term Committee, 2008). However, the terminology confusion due to the variation within the conservation tillage practices is quite often. This confusion could be related to the variation in tillage frequency, depth, soil disturbance, tools and crop residues between the conservation tillage systems. Nonetheless, these practices have three major common principles including presence of crops residue; minimum soil disturbance; and crops rotation (Reicosky, 2015).

Baker et al., (2002) mention that restriction of conservation tillage with 30% of crop residue alone is not sufficient to view the broad and inclusive contents of the conservation tillage which include the conservation of crops residue, energy, time, soil (soil nutrients, structure and fauna) and environment. In fact, conservation tillage is one of the practiced measures to cope with climate change (Bedeke et al., 2019; Morugán-Coronado, et al., 2020) and have proven to be less energy consumption and CO$_2$ emission in regarding to machinery work (Moitzi et al., 2021) and reduce CO$_2$ emission due to soil organic matter breakdown (Abdalla et al., 2013). For soil, conservation tillage systems are well documented as enhancer for soil properties, where it reduces soil bulk density (Gholami et al., 2014), soil compaction and erosion (Martínez et al., 2013) and increase organic matter content, water infiltration, soil moisture content, aggregate stability, macro/microorganisms’ activities and enzymatic activities (Amini
Accordingly, this lead to improve plants root development, which enhance its ability for water absorption (Gangwar et al., 2019) and fertilizers use efficiency (Abedi et al., 2010), which indeed leads to higher yield production (e.g. grain and straw) (Celik et al., 2011; Lopez-Garrido et al., 2014) and improve some morphological parameters such as tillers number, spike characteristics, stem length and other traits (Ali et al. 2016). Furthermore, Lopez-Garrido et al. (2014) reported 6.45% increment in wheat grain under reduced tillage comparing to conventional (traditional) tillage. Also, Acar et al. (2017) indicated that reduced tillage revealed the highest wheat total yield under rain fed conditions (6.29 t ha\(^{-1}\)) comparing to the conventional tillage that produced (5.66 t ha\(^{-1}\)) as a total yield.

It was also indicated that conservation tillage reduces the surface water contamination as a result of reduction the water runoff that carried with it the soil sediments and the agricultural chemicals (pesticides and fertilizers). Moreover, it improves the soil structure and thus water holding capacity. Furthermore, it provides better living opportunities for some insects, birds and tiny mammals by providing them with habitat and food (Holland, 2004; Amini and Asoodar, 2014). However, the conservation tillage systems may affect or affected-by many factors like soil, plant, machinery, implementation duration and climatic factors (Abdalla et al., 2013), which lead to variation in production among these systems (Shahzad et al., 2016).

On the other hands, conservation tillage systems are proved to emit N\(_2\)O that could be either equal or more and sometime less than conventional tillage based on soil properties, soil water content and temperature (Abdalla et al., 2013). Also, the initial transformation stages to conservation tillage are accompany with some negative impacts that could change for the better over time (Brouder and Gomez-Macpherson, 2014) such as soil surface layer compaction, higher weeds density (Abdalla et al., 2013), and higher bulk density (occurred due to the soil regain humus content, soil structural constancy and pore space), resulting thereby in lower yield (Pittelkow et al, 2015).

Later on, when the soil is restructured, the bulk density decreased and equalized (Lampurlanés and Cantero-Martínez, 2003). Which require 1.5 year as initial stage, 5 years as transitional stage and 14 years until the stabilization stage of the soil physical properties (Peigné et al., 2018).
1.3.2.3. Reduced tillage (minimum tillage):
This type of tillage either considered part of the conservation tillage systems (Soil Science Glossary Term Committee, 2008) or dependent type (Mitchell et al., 2007). In fact, reduced tillage permits a reduction in tillage depth and frequency and 15-30% of crop residue (Krauss et al., 2020).

1.4. Fertilizers:

1.4.1. Definition and rational:
Fertilizers is defined by the conservation agriculture information center as "any organic or inorganic material of natural or synthetic origin (other than liming materials) that is added to a soil to supply one or more plant nutrients essential to the growth of plants" (Soil Science Glossary Term Committee, 2008). Fertilization is considered as one of the adaptation strategies that practiced for improvement of soil properties, production enhancement, and coping with climate change (Kumar et al., 2019). Indeed, the utilization of manure to compensate the nutrients that are taken up by the plants and to increase the production were practiced by ancient civilizations in Egypt, Rome, Greece (Nene, 2018), Western Europe (Kanstrup et al., 2013), India (Feller et al., 2012) and the Fertile Crescent (Araus et al., 2014). However, during the past two decades, the world oriented toward the synthesized fertilizers (inorganic fertilizers) mainly to get better crop quality and higher production in shorter time (Tayoh et al., 2016; Nene, 2018).

1.4.2. Fertilizers Importance and effects:
Fertilizers play a key role in enhancing crop productivity and plant characteristics (Ghaley et al., 2018), rangelands (Roul et al., 2017), fruit tree orchards (Song et al., 2012), intensive-greenhouses cultivation (Arshad et al., 2014) and soilless agriculture (Kinoshita et al., 2014), hence, improve thereby food security (Prasad, 2009).

Fertilizers may influence soil chemical, physical and biological properties; and plants growth and development (Iqbal et al., 2021). In fact, fertilizers could be used directly or indirectly to control and/or to mitigate biotic stress (pests and diseases) and abiotic stress (Meharg and Meharg, 2015; Roul et al., 2017; Dimkpa et al., 2020). Also, they enhance the plant defense mechanisms that include formation of mechanical barriers (thicker cell wall) forming therefore a physical defense against insects and produce
natural defense compounds (e.g. antioxidants) that protect plants from pathogens (Spann and Schumann, 2010).

However, to guarantee the fertilizers desired-outcomes, it should be taken in considerations at planning and application phase that fertilizers impact could influenced by soil properties such as moisture content, aeration, structure … etc. (Zheng et al., 2003), tillage systems (Singh et al., 2020), temperature, precipitation (Jabloun et al., 2015), plant characteristics like species, developmental stage … etc. (Dursun et al., 2010) and fertilization practices (Nosratabad et al., 2017), fertilizers quantities and combinations (Ghaley et al., 2018), timing (Efretuei et al., 2016; Liu et al., 2019), application forms (Iqbal et al., 2021) and the used tools (Devi et al., 2020)). Carefully, bio-stimulants could also be used as additives to fertilizers (Drobek et al., 2019) in order to increase fertilizers, use efficiency and nutrients uptake by plants (Halpern et al., 2015).

1.4.3. Fertilizers types and application forms:

Generally, researchers classify the fertilizers into organic and inorganic fertilizers and compared between them to evaluate their effects on different parameters related to crops, soil and environment (Abedi et al., 2010; Šimon and Czakó, 2014; Hammad et al., 2020). More precisely, fertilizers could be classified into many categories according to their formulation that could be solid or liquid (Tallaksen et al., 2015). Also, they could be categorized according to their application form, where they might be amended directly on the soil (e.g. broadcasting, banding …etc.), dissolved or diluted in water and irrigated to the plants or sprayed on the plants (foliar application). Moreover, the fertilizers could be classified according to their components such as single or multiple fertilizers; or macronutrients, secondary macronutrients and micronutrients (Malhotra, 2016). Another promising and innovative type of fertilizers is the Nano fertilizers and the controlled and slow-release fertilizers that regulates the nutrients release and increase the nutrients use efficiency more than the conventional fertilizers (Elizabath et al., 2019; Wei et al., 2020).

1.4.3.1. Organic fertilizers:

Organic fertilizers could be originated either from plants residues, animal manure or by mixing both of them together and they are able to be used as a fresh or decomposed organic matter (Wei et al., 2020). Organic fertilizers including a wide range of forms
and applications and they may be amended to any type of soil and plants with low restrictions and hazards (e.g. manure, compost, green manure, tea compost, vermicompost …etc.) (Hazra, 2016). Recently, biofertilizers starts to be commonly used as a promising organic fertilizers toward improving different production field crops parameters in many regions of the word (Hassan and Bano, 2016).

The advantages of organic fertilizers exceed its improvements to the plant's parameters such as production and disease resistant to improve the soil properties (Al-Sari et al., 2018), reduce soil moisture evaporation, increase nutrients uptake (Dimkpa et al., 2020), reduce the environmental pollution and mitigate the climate change impact (Al-Sari et al., 2018). Field crops including wheat are highly influenced by fertilization practices, where organic fertilizers like animals' manure (e.g. sheep, poultry … etc.) and green manure are reported to increase the wheat production and increase the N content, organic matter content, water holding capacity and water infiltration in the soil more than inorganic (Hammad et al., 2020). In other studies, chicken manure, cow manure and sheep manure revealed higher total wheat yield than the unfertilized treatments by 15.7, 12.8, 11.7 and 11.3 t ha$^{-1}$ respectively (Rasul et al., 2015). Moreover, Hammad et al. (2020) reported that the wheat that was treated with organic fertilizers revealed 67% higher seed protein content in comparing to the control and 2% in comparing to the chemical fertilizers. However, some problems could face the farmers while using the organic fertilizers -especially the fresh manure- like heavy growing of weeds and bugs attraction. Also, they are slow-acting in response to nutrients deficiency that may occur with plants (Hazra, 2016).

1.4.3.2. Inorganic fertilizers:
The use of inorganic (chemical) fertilizers has increased globally in response to the increasing human population and their needs for food (Nagendran, 2011). Comparatively, it is considered the most important criterion between the agricultural inputs and the significant increment in the agricultural production. In addition, inorganic fertilizations such as silicon is well documented as an effective measure to improve rice response to abiotic stress such as drought, salinity, high temperature, UV and metal toxicity (Meharg and Meharg, 2015). Also, Potassium enhances plants response to frost and heat stress, increase the photosynthetic ability in wheat, reduces the effect of Cd toxicity in broad bean (Hasanuzzaman et al., 2018). In fact, the intensive use of chemical fertilizers affects negatively air (e.g. air pollution by greenhouse gases, acidic
rain … etc.), water (e.g. groundwater contamination, reduction the drinking and domestic water quality, water eutrophication, water toxicity … etc.), and soil (e.g. degradation, salinity, infertility, damaging flora and fauna … etc.). However, many researchers have studied the chemical fertilizers and the factors that may influence their impact (e.g. soil properties) in order to optimize their use according to recommended quantities to insure higher production and avoid the excessive amendment that could cause economic loses, soil deterioration as a result of salts accumulation, water contamination as a result of nutrients leaching, drainage and runoff in addition to air pollution by the greenhouse gases (Malghani et al., 2010; Yilmaz et al., 2010; Savci, 2012; Nosratabad et al., 2017).
CHAPTER II. Study goals:
The general goal of this study is to evaluate the impact of different tillage and fertilization practices on morphological features and yield components of winter wheat (var. Yellow Heteya), which grown under rain-fed conditions.

2.1. Goal of the first study: to determine the effects of different tillage practices on the morphological parameters and productivity of wheat (var. Yellow Heteya) especially in semi-arid areas.

2.2. Goal of the second study: to study the effects of different tillage operations (number and depth) as well as diverse fertilizations (organic and inorganic with different ratios) as a mean of conservation agriculture on the morphological and yield parameters of wheat (var. Yellow Heteya) especially in semi-arid areas.
CHAPTER III. General Materials and Methods:

3.1. Site description:

3.1.1. Location:

The experiment was taken place in Za'tara town that located at latitude 31.67 and longitude 35.26 in the eastern slopes of Bethlehem governorate at an altitude of 577m above sea level. Generally, the area is classified as semi-arid region (Fig. 3.1) (Land research center, 2020).

3.1.2. Soil characteristics:

Before plantation, soil sampling was conducted on October, 2018; via collecting 10 representative samples from 10–30 cm depth. Samples were then homogenized and subjected to different analysis that conducted at the laboratory of soil and water, Hebron University. Soil texture has been determined by pipette method (Pansu and Gautheyrou, 2003). For macro element; total nitrogen analysis was achieved by Kjeldahl method (Pansu and Gautheyrou, 2003), phosphorus and potassium by atomic absorption spectrophotometer (Brupbacher, 1968). Organic matter was analyzed by Walkley-Black method; acidity by pH meter and salinity by the electrical conductivity meter (Whitney and Brown, 1998). Soil moisture was analyzed by the drying method in the oven (Pansu and Gautheyrou, 2003). Soil analysis were interpreted according to the manual of the laboratory of soil science at College of Agriculture, Hebron University. Soil analysis revealed clay-loamy texture (containing 34.76% clay content), neutral pH (pH=7.26), low organic matter content (1.38%), low salinity (EC= 0.249 ds/m), low phosphorus and nitrogen content (8.19 ppm and 0.119% respectively) and high potassium content (291.43 ppm).

3.1.3. Climate:

During the last decade, an average annual rainfall of about 390 mm is characterized the experimental area, however the total rainfall in the rainy season of 2018/2019 was exceptional with 621 mm and the peak was in February, 2019 (Fig. 3.2). Yet, uneven rainfall distribution and erratic precipitation characterized that season, but also the rain was fallen in 41 rainy days (Fig. 3.3) starting from Oct 25th, 2018 till April 21st, 2019. In addition, about 40% of the rain was fallen in three heavy raining days. During the growing season, minimum temperature was recorded in January 2019 with 8.1°C and maximum temperature was registered in April 2019 with 22.2°C (Fig. 3.4).
Fig. 3.1. Maps showed the aridity index of targeted study site (the left) and the average annual precipitation (the right).

Fig. 3.2. Monthly precipitation (mm) in the experimental area during November 2018 – April 2019. (Source: Za'tara Secondary School rainfall monitoring station database).

Fig. 3.3. Daily rain (mm) in the experiment area November 2018 – April 2019. (Source: Za'tara Secondary School rainfall monitoring station database).
3.2. Plant materials, experimental design, and plantation:

To avoid any previous plantation effects, the experimental site has not been planted in the last three years and the plant residue was less than 10%. Here, a field investigation using wheat *Triticum aestivum* L. (var. Yellow Heteya) was implemented in November 2018. This variety is commonly planted in Palestine and it is characterized by a moderate grain production, high straw production, and medium maturity (Salama *et al.*, 2014). The targeted variety was investigated by conducting two field experiments depending on number of tillage practices in combination with different quantities/ratios of organic and non-organic fertilizers including decomposed sheep manure, triple superphosphate (TSP), and ammonium sulfate (AS) as the following:

### 3.2.1. Tillage treatments:

3.2.1.1. Conventional tillage (CT), twice tilled: This operation system is commonly used (10-12 cm depth) by the Palestinian farmers. Here, the plot was tilled twice, one before the first rainfall and the second in November 25, 2018 (when the land is partially dry to enable tillage). In this type, sowing occurred manually.

3.2.1.2. Three introduced conservation tillage systems: any form of tillage that minimizes the number of tillages passes to reduce soil erosion and compaction, these including:
3.2.1.2.1. Reduced/minimal tillage (RT), one time tillage with 10-12 cm depth which was taken place in November 25, 2018. Here, sowing also occurred manually.

3.2.1.2.2. Conservation tillage (C8) at 8 cm depth, also done at the same date.

3.2.1.2.3. Conservation tillage (C4) at 4 cm depth, also done at the same date.

The latest two conservation tillage systems have been accomplished via modifying local sowing machine (Fig. 3.1) that equipped with shovels to split the soil surface for seed placement, in which the sowing depth was adjusted to 8cm and 4cm and the number of seeds per dunum was controlled to 12.5 kg/dunum (dunum=1000m²) for all treatments. While CT and RT sites were tilled by using sweep duck foot cultivator.

![Conservation tillage sowing machine.](image)

The conservation tillage sowing machine was heavy and more subjected for shaking due to the topsoil stones that were stuck in the shovels. To the contrary, the sweep duck foot cultivator was easier to move and less affected by shaking.
3.2.2 Fertilization treatments:

Fermented sheep manure (piled for one year) was added manually to the site at the beginning of November 2018. The tri-superphosphate (TSP) was added at the planting date by the sowing machine. Laterally, the Ammonium sulfate (AS) was added manually in the 12th of February, 2019. The fertilization treatments were as the following:

3.2.2.1. (\(M_{6m}^3\)) Manure 6m\(^3\)/dunum.

3.2.2.2. (\(M_{3m}^3/TSP_{6.25kg}/AS_{6.25kg}\)) Manure 3m\(^3\)/dunum + 6.25kg/dunum TSP + 6.25 kg/dunum AS.

3.2.2.3. (\(M_{3m}^3/TSP_{12.5kg}\)) Manure 3m\(^3\)/dunum +12.5 kg/dunum TSP.

3.2.2.4. (\(M_{3m}^3/AS_{12.5kg}\)) Manure 3m\(^3\)/dunum +12.5 kg/dunum AS.

The experiment was placed out in two designs, where the first part was laid out in a randomized block design because the comparison included one factor (tillage system). While in the second part there were two factors (tillage’s and fertilizers), for that it was laid out in a factorial randomized block design. Also, every treatment gets 3 replications using the net plot size of 40 m\(^2\) area (8m*5m) per replicate. To isolate the plots as well as to facilitate the follow-up process (cultural practices, measurements, etc.), one-meter corridors between and around the plots were used. Adoption rate of 500 gram of seeds / replicate (equivalent to 12.5 kg/dunum), were sown. Simple random sampling was carried out on the 21st of May, 2019, when the kernel became hard and cannot be dented by thumbnail and the moisture content of the kernel get to 12-13%.

3.3. Measured and evaluated parameters:

To evaluate the response of wheat to drought stress, many parameters are commonly used involving production characteristics (total yield weight, grain yield, straw yield, and morphological characteristics (tillering, stem length, spike length, spike length without awns and number of seeds per spike) (Khaliq et al., 2008; Monneveux et al., 2012; Alsalimiyia et al., 2018; Boussakouran et al., 2019).

Sampling procedure was carried out in simple random sampling method which is suitable for the homogeneous small plots (Elzinga et al., 1998). Samples were selected randomly (3 samples/plot) with total amount of 96 samples of one-meter square area.
that were harvested, labeled, weighed, measured, threshed and recorded separately. Accordingly, yield records were turned out to kg/dunum.

3.4. Data analysis:

Data were statistically analyzed using one-way analysis of variance (ANOVA), followed by Least-Significance Difference (LSD) that using to compare the mean of individual parameter and Kruskal–Wallis test for some characteristic parameters that infract the assumptions of ANOVA by SPSS 22, at 95% confidence.

4.1. Abstract:

Drought is the main agricultural constraint that reduces crop productivity in the Middle-East in general including Palestine with no exception. The main goal of the present study is to evaluate the impact of four tillage technologies including conventional tillage (twice-tilled), reduced tillage (one-tilled), conservation tillage at 8 and 4 cm depth on morphological features and yield components of winter wheat (var. Yellow Heteya), grown under semi-arid conditions at the Eastern-slope of West-Bank, Palestine. Significant differences among the examined parameters were observed. Overall, the examined tillage types and sowing depths, the reduced tillage system presented significant higher yield, stem length, and spike parameters values followed by the control (conventional), whereas both 4 and 8 cm tillage types were exhibited the lowest values. Significant lowest values presented in the conservation systems might be explained by its initial stage of transformation to the conservation system which commonly needs many years, however still they are promising long-term technologies.

**Key words:** *Triticum aestivum* L., drought, tillage system, yield, Palestine.

4.2. Introduction:

Wheat production and demand has been increasing worldwide from year to year and from country to country. In 2019 the world wheat production was about 763.6 million ton, which is 4.2% higher than 2018 (FAO, 2020). Such growing trend is due mainly to its high demand for food and nutrition security as well as for animal feed. Despite its global upward growing and multiple benefits; climate change, water scarcity and drought stress are a serious threatening challenges facing the world wheat production and productivity not only for todays but also it is predicted to increase in the future (Araya et al., 2016).

In Palestine, wheat is among the ancient grown cereal crops and Palestinians are one of the eldest civilizations that improved its farming systems and continuously upgraded its agricultural practices. The anthropological evidences showed that Natufians whom
arisen in Palestine (about 13000 BP) were the first to domesticate cereals in general and wheat in particular for the aims of food and feed production (Bar-Yosef, 1998). Despite the amusing history of wheat domestication, cultivation and improvement in Palestine; severe decline in wheat production and productivity were clearly noticeable during the last decade “from 245,414 dunum of cultivable land producing 44,404 ton in 2010 to 133,475 dunum with only 23,773 ton in 2018” (Palestinian Ministry of Agriculture, 2018). Currently and unluckily, the local wheat production doesn’t exceed 5% from our consumption (Palestinian Ministry of Agriculture, 2020).

Reasons behind such decline might related to the detectable climate change in the region including increase number of droughts, lower average precipitation rate, more marked changes in the distribution of precipitation from one year to the next, with winter getting shorter and extensive (Basheer-Salimia and Atawne, 2014; Abhinandan et al., 2018), particularly in the southern and eastern slopes of Palestine (Basheer-Salimia and Ward, 2014). Such situation led to deterioration and disappearance of many of the local wheat varieties which supposed to adapt the imposed condition. For that and to cope with the climatic change it is important to find out the best agricultural practices and use the most suitable drought-tolerant wheat genotypes (Alsalimiyia, et al., 2018). Some researches indicate that tillage depth and number of tillage’s practices influence the wheat productivity (Plum et al., 2009; Workayehu, 2010; Alam, et al., 2014). Here, and for the first time we introduced a new approach of tillage operations in Palestine as a mean of conservation agriculture depending on minimal number of tillage’s as well as fixing the tillage depth. Toward this end, a sowing machine has been locally modified, in which the sowing depth and the number of seeds per dunum could be controlled and adjusted. In this experiment, the effect of number of tillage’s and tillage depth practices were studied to determine its effect on the productivity of wheat (var. Yellow Heteya) especially in semi-arid areas. This variety has been targeted since it showed superiority production (Alsaleimyia et al., 2018), among the most common cultivable wheat genotypes grown in Palestine.

4.3. Materials and methods:

4.3.1. Treatments:

In this experiment only 4 tillage treatments were studied out in a **randomized block design (RBD)** and included the conventional tillage (or traditional tillage) in addition to
three introduced conservation tillage systems: and included the reduced/minimal tillage system (one time tillage), conservation tillage at 8 cm depth and conservation tillage at 4 cm depth.

4.4. Results:

Soil analysis revealed neutral pH (pH=7.26), clay-loamy texture (containing 34.76% clay content), low organic matter content (1.38%), low salinity (EC= 0.249 ds/m), low nitrogen and phosphorus content (0.119%, and 8.19 ppm respectively), and high potassium content (291.43 ppm). In general, significant differences among the examined parameters were observed. Overall, the examined tillage types and sowing depths, the reduced tillage system presented higher production values of total sample weight (638 Kg/dunum) as well as total straw weight (584 Kg/dunum), followed significantly by the control (conventional). Whereas, both 4 and 8 cm tillage types were exhibited the lowest values. In contrary, the control showed significantly higher seed weight, followed by the reduced tillage system. Meanwhile, the remaining introduced conservation tillage’s presented low seed weights. Concerning the 100 grains weight variable, no significant differences were found among the four evaluated tillage systems (Table 4.1).

Table 4.1. Comparison between four types of tillages and sowing depth using different wheat yield parameters (Mean* ± S.E).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Conventional (twice-tilled) (control)</th>
<th>Reduced tillage (one-tilled)</th>
<th>8cm tillage</th>
<th>4 cm tillage</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt. of Sample (kg/dunum)</td>
<td>475.00±4.04&lt;sup&gt;b&lt;/sup&gt;</td>
<td>638.67±41.48&lt;sup&gt;a&lt;/sup&gt;</td>
<td>68.33±21.18&lt;sup&gt;d&lt;/sup&gt;</td>
<td>184.00±31.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>87.0</td>
<td>0.00</td>
</tr>
<tr>
<td>Wt. of Straw (kg/dunum)</td>
<td>409.83±4.90&lt;sup&gt;b&lt;/sup&gt;</td>
<td>584.23±39.95&lt;sup&gt;a&lt;/sup&gt;</td>
<td>58.87±20.98&lt;sup&gt;d&lt;/sup&gt;</td>
<td>168.95±30.76&lt;sup&gt;c&lt;/sup&gt;</td>
<td>74.5</td>
<td>0.00</td>
</tr>
<tr>
<td>Wt. of seeds (kg/dunum)</td>
<td>65.17±0.85&lt;sup&gt;a&lt;/sup&gt;</td>
<td>54.44±4.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.46±3.28&lt;sup&gt;d&lt;/sup&gt;</td>
<td>15.05±1.82&lt;sup&gt;c&lt;/sup&gt;</td>
<td>100.3</td>
<td>0.00</td>
</tr>
<tr>
<td>Wt. of 100 grains (gm)</td>
<td>3.73±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.36±0.14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.44±0.23&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.40±0.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.3</td>
<td>0.35</td>
</tr>
</tbody>
</table>

*: Means within rows using different letters are differ significantly at the P ≤ 0.05 level (using one way ANOVA analysis). Morphologically, the measured parameters (Table 4.2) revealed significant variation among the examined tillage technologies, in which the two conservation systems (4cm and 8cm tillage systems) have shown no significant variation between each other in
term of tillering, but when comparing them to the reduced tillage system and the control, the conservation systems showed significantly lower values.

Table 4.2. Comparison between four types of tillages and sowing depth using different wheat morphological parameters (Mean* ± S.E).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Conventional (control)</th>
<th>Reduced tillage</th>
<th>8 cm tillage</th>
<th>4 cm tillage</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tillers</td>
<td>2.00±0.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.00±0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.20±0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.45±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.15</td>
<td>0.01</td>
</tr>
<tr>
<td>Stem length (cm)</td>
<td>63.74±2.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>73.83±1.63&lt;sup&gt;a&lt;/sup&gt;</td>
<td>47.30±1.69&lt;sup&gt;d&lt;/sup&gt;</td>
<td>53.84±1.72&lt;sup&gt;c&lt;/sup&gt;</td>
<td>34.72</td>
<td>0.00</td>
</tr>
<tr>
<td>Spike length (cm)</td>
<td>12.45±0.17&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>14.34±0.65&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12.64±1.63&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.75±0.17&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.47</td>
<td>0.07</td>
</tr>
<tr>
<td>Length of spike-awns (cm)</td>
<td>4.21 ±0.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.29 ±0.30&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.09 ±0.42&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.09 ±0.14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.58</td>
<td>0.07</td>
</tr>
<tr>
<td>No. seeds per spike</td>
<td>22.33±2.2&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>29.73±2.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.87±2.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>19.83±1.8&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.90</td>
<td>0.03</td>
</tr>
</tbody>
</table>

*: Means within rows using different letters are differ significantly at the P ≤ 0.05 level (using one way ANOVA analysis).

Generally, the reduced tillage system has excelled significantly the other three treatments in term of stem length, spike length, length of spike without awns and number of seeds per spike. The results in this experiment presented insignificant difference between the one tillage system and the control in regard of tillering (2 for each). Meanwhile, the two introduced conservation systems revealed the lowest values (C4 1.45 and C8 1.2). Indeed, the reduced tillage system revealed significantly the highest value of stem length (73.83cm) followed significantly by the control as presented in our experiment. Conversely, the two introduced conservation systems showed lowest values of stem length. Also, the reduced tillage system presented significantly highest spike length (14.34cm) followed significantly by the two introduced conservation systems. In contrary, the control presented the lowest spike length but without significant variation comparing with the two introduced conservation systems.

The reduced tillage system revealed the highest spike length without awns (5.29cm) comparing to the other examined treatments that showed insignificant variation among each other’s. Regarding the number of seeds per spike, the reduced tillage system also
presented significantly the highest number of seeds per spike (29.73 seed/spike) followed significantly by the control. Meanwhile, the two introduced conservation systems presented the lower values but without significant variation comparing to the control.

4.5. Discussion:
Climatic change is the key limitation for wheat production in arid and semi-arid areas (Öztürk and Aydin, 2017). Therefore, many researchers are seeking to explore ways to cope with drought as a direct result of climate change such as breeding (Tadesse et al., 2018), genetic engineering (Yadavq and Mishra, 2020), drought-tolerant genotypes (Alsalimiyia, et al., 2018) and manipulating different agricultural practices (Hatfield and Dold, 2018; Kumar et al, 2019). Tillage systems, frequency and depths are aspects of the agricultural practices that have been practiced by farmers since the rise of agriculture (Singh and Singh, 2017), and studied for many crops. However, very few studies were reported about the effect of tillage systems on wheat productivity in Palestine.

In this study, conventional (twice-tilled) and introduced (one-tilled, 4 cm and 8cm depth) conservation tillage’s revealed very low production comparing with the world average wheat production which is about 342.5 kg/dunum (FAOSTAT, 2018). This indeed could comply with the harsh environmental conditions which characterize our region (Basheer-Salimia and Ward, 2014; Alibaba, 2017; Safi and Mohammad, 2019) compromising low water availability, low soil organic matter content, and low nitrogen as well as phosphorus content which clearly analyzed in the study site prior conducting this experiment. In addition, such stress is negatively affecting wheat grain filling stage resulting thereby in low production components (Chen et al., 2019). Physiologically, reduction of relative water content closes stomata, reduces stomatal conductance, affects thereby photosynthesis negatively resulting in low crop productivity (Ahmad et al., 2018).

However, the reduced tillage (one-tilled) system presented significantly higher total production (638 kg/ dunum total yield which is 584 kg straw and 54 kg grain) over the conventional tillage (twice-tilled; 475 kg/ dunum total yield which is 409 kg straw and 65 kg grain); meanwhile both systems (one and twice-tilled), exhibited superior
significance production comparing with 4 and 8cm tillage’s by 184 and 68 kg, respectively.

The significant higher straw exhibited in the one-tilled system might be related to the higher content of *Arbuscular mycorrhizae* that induced in the top soil as a result of the reduced tillage (Van-Groenigen *et al.*, 2010), consequently this reduce nitrogen lose and increase phosphorus uptake (Sosa-Hernández *et al.*, 2019), resulting therefore in incorporating and integrating with the soil water content as well as soil physical characteristics, leading thereby to higher straw yield (Zhang *et al.*, 2020). In contrary, lower grain production presented in the reduced tillage comparing to the conventional tillage is in agreement with the finding of Peigné *et al.* (2014), who found that low grain production is characterizing the initial transformation stage from conventional to conservation system, that accompanies compaction of soil surface layer, more weeds density (Abdalla *et al.*, 2013), and higher bulk density which occurred while the soil regaining humus content, structural constancy and pore spaces, resulting thereby in lower yield (Pittelkow *et al.*, 2015).

Concerning the 4 and 8 cm tillage’s; the revealed lowest grain and straw production could be explained by the prior accumulated soil surface layer compaction (especially in the conservation systems) which limits the root development in the soil surface zone where the soil water content is less than the other two treatments (Małecka *et al.*, 2015; Shahzad *et al.*, 2016; Biberdzic *et al.*, 2019; and Gangwar *et al.*, 2019). Furthermore, shallow depths leads to high evaporation rate (more water stress) resulted therefore in low production (Brunel *et al.*, 2013). Such stress is cascading the stomatal closure and reduces CO₂ concentration then decrease the photosynthesis rate which lead to restrain dry matter production (Maralian *et al.*, 2010).

Additionally, the lack of plant residue or mulching increases the evaporation and affects temperature fluctuation as well resulting thereby in low production (Büchi *et al.*, 2018). Indeed, the reduced soil temperature in autumn due to lack of cover and the closeness to the surface atmosphere affects negatively the wheat seeds germination which also resulted in low production (Pittelkow *et al.*, 2015; Salem *et al.*, 2015).

It is worth to mention that, high densities of blind mole burrowing activities were noticed at the 4 and 8 cm tillage’s systems, which probably cause soil and plant physical damage in addition to the direct feeding on the herbaceous and grass plants (Lövy *et al.*, ...
2015); in contrary, its' population decreased in the areas of one and twice-tilled systems due to their tunnels destruction and the reduction in the vegetation richness (Csorba et al., 2015).

When comparing between the two introduced (4 and 8 cm) minimal tillage systems we found that the 4cm tillage presents significantly higher total production. This could be related to the higher soil water retention in the surface layer (0-5 cm) compared to the lower layers, which could be related to the higher soil organic carbon in the surface layer (Ramos et al., 2019) which led to more grain and straw production (Mojid et al., 2009).

Regarding the weight of 100-grains variable, no significant variation among the evaluated treatments was observed; nevertheless, the conventional tillage was slightly higher than conservation tillage and reduced tillage treatments. Similar result was also obtained by Gholami et al. (2014) who found highest 1000-grain weight in conventional tillage and related this to the higher soil water content during the grain filling stage. Furthermore, Khorami et al. (2018) stated that the soil water content is reduced as a result of the high bulk density that performed in the conservation tillage in the absence of residue.

In general, transition from the conventional to the conservation system revealed reduction in total yield in the initial period (Pittelkow et al., 2015) due to the increment in bulk density, decline the rate of oxygen diffusion and soil temperature (Lampurlanés and Cantero-Martínez, 2003). However, it could be reduced with time (Brouder and Gomez-Macpherson, 2014), increasing thereby the soil organic carbon storage (Xu et al., 2019); enhancing the soil chemical component and biological activity (Martínez et al., 2013), and improving the soil physical properties leading therefore to higher production (Kumar et al., 2018).

By the time, conservation systems might present higher yield compared to the conventional system due mainly to the effect of accumulative plants residue (Wang et al., 2012), and to the higher soil organic carbon that resulted from the adoption of the conservation system (Murillo et al., 2004).

Concerning wheat morphology, it is well documented that climatic conditions, soil properties and tillage systems are the main criteria’s affecting wheat morphological characteristics including tillering, stem length and different spike variables (Leghari et al., 2015; Ali et al., 2016). Here, these latest features were significantly higher in the reduced (one-tilled) system over the other examined tillage types. This superiority
might be explained by the resulted higher water content and the lower bulk density over the other conventional and conservation (4 and 8 cm) tillage systems (Gholami et al., 2014; Chaghazardi et al., 2016). In contrary, Ruiz et al., (2019) stated that higher values of morphological characteristics were registered in the conservation systems rather than conventional ones. Indeed, this contradiction probably related to the long-term effects of the conservation systems especially on soil properties (Pittelkow et al., 2015).

Furthermore, the lowest values of tillering in the conservation systems comparing to the conventional and reduced ones, is related to the soil compaction that reduced the tillering rate (Wu et al., 2018), as well as to the low soil moisture content (Basheer-Salimia and Atawnah. 2014; Al-salimiyia et al., 2018). Similar results were also achieved by Leghari et al. (2015) who stated lower tillering values for conservation systems compared to conventional and reduced tillage's.

Interrelated, the higher total yield that was presented in the reduced (one-tilled) system was positively related to the higher stem length and spike characteristics. Similar results also revealed by Ali et al. (2016) who found significant effect for tillage systems on spike characteristics.

4.6. Conclusions:
The reduced tillage system is recommended for such climatic and edaphic conditions due to higher yield and less costs comparing to the other treatments. Since the conservation tillage systems are less efficient at the initial transformation stage from conventional to conservation, it is still a promising long-term approach. More researches are needed toward evaluating these introduced conservation technologies at a longer period.
CHAPTER V: Effect of Different Tillage and Fertilization Interventions on Wheat (*Triticum aestivum* L.) Production in Palestine

5.1. Abstract:

Wheat (*Triticum aestivum* L.) is considered the main aspect of food security in the Middle-East including Palestine. This important crop testifies sharp decline in its productivity due to many reasons including climate change and its consequences in particular. This study was carried out in the eastern slopes of Bethlehem governorate that is classified as arid to semi-arid areas in the growing season 2018/2019. The experiment was laid out in a factorial randomized block design, for the aim of investigating the effect of different tillage (conventional tillage (CT) and three conservation tillage systems, reduced tillage (RT), conservation tillage at 8cm (C8) and conservation tillage at 4cm depth (C4)). In addition to their combination with different fertilization types (sheep manure (M), tri-superphosphate (TSP) and ammonium sulfate (AS)) and ratios as the following (manure 6m³/dunum (M₆m³), manure 3m³/dunum+ TSP 6.25 kg/dunum+ AS 6.25 kg/dunum (M₃m³/TSP₆.ₒ₅kg/AS₆.ₒ₅kg), manure 3m³/dunum+ TSP 12.5 kg/dunum (M₃m³/TSP₁₂.₅kg) and manure 3m³/dunum+ AS 12.5 kg/dunum (M₃m³/AS₁₂.₅kg)) in addition to the control that was tilled without any fertilization treatments. Generally, our results revealed the superiority of the RT× M₆m³ in term of grain yield production. On the other hands, RT× M₃m³/TSP₁₂.₅kg is recommended to increase straw production. This short-term study is definitely not sufficient to reveal the impact of the examined tillage and fertilization practices, but it gives indicators for the possible effects of these practices that need more investigation on longer term.

**Key worlds:** *Triticum aestivum* L., drought, tillage system, fertilization, yield, Palestine.

5.2. Introduction:

Wheat is considered the most important human food and the top used cereal worldwide. Its significance is not only raised from being human food, but also as animal fodder. In addition, the gluten and wheat starch are used in many industries such as food additives, baby foods, cosmetics …etc. (Igrejas and Branlard, 2020). In Palestine, wheat grains are commonly used in the Palestinian cuisine for bread, freekeh, jresheh, burghul and some other products, in addition its straw is used as animal fodders (Palmer, 2002). In spite of
the importance, wheat production in Palestine testifies steep decline during the last decades (Albaba, 2017; Al-salimiyia et al., 2018), where wheat production has fallen by 46% between 2010 and 2018 (PCBS, 2018). Main reason beyond this deterioration is climate change particularly with regard to heat and drought (Abu Hammad and Salameh, 2018; Mizyed, 2018), and their impacts on crop growth, development and production (Basheer-Salimia and Ward, 2014; Al-salimiyia et al., 2018). Indeed, plants are influenced variously according to the plant species, life stage and stress degree (Murtaza et al., 2016). This influence manifest when heat and/or drought exceed the threshold levels and last for sufficient time to cause irreversible damage (Lipiec et al., 2013).

In general, wheat facing drought by different strategies and mechanisms including but not limited to morphological, anatomical, physiological, biochemical, and molecular modifications and changes (Al-salimiyia et al., 2018). In fact, these strategies are usually used jointly and complexly by the plant depending mainly on the plant species (genotypes) and the developmental stages (Darai et al., 2016).

Climate change impacts especially drought could be mitigated and adapted by improving drought tolerance species (Farooq et al., 2018) which is a long-term process; increasing moisture storing capacity of soils (Wery et al., 1993); and using appropriate soil management and soil amendments (Fazily and Hunshal, 2019). Since soil is more manageable part, researchers manipulate the agricultural practices like tillage systems, mulch, sowing rate and fertilization to improve soil properties that lead to better water use efficiency and thus higher yield (Lipiec et al., 2013). Indeed, suitable management of soil practices has proven to influence wheat production, in which minimal tillage operations as a mean of conservation agriculture revealed higher production and morphological traits over the conventional systems over the long-term (Khorami et al., 2018; Ruiz et al., 2019). Furthermore, soil amendment by means of organic and inorganic fertilizations found to increase wheat productivity; however organic fertilizers (manure) found also to improve soil health and decrease water pollution (Mukhtiar et al., 2018).

Here, different tillage operations (number and depth) as well as diverse fertilizations (organic and inorganic with different ratios) as a mean of conservation agriculture were studied to determine their effects on the productivity of wheat (var. Yellow Heteya)
especially in semi-arid areas. This variety has been targeted since it showed superiority production (Alsaleimyia et al., 2018), among the most common cultivable wheat genotypes grown in Palestine.

5.3. Materials and methods:

5.3.1. Treatments:

The experiment was laid out in a factorial randomized block design. Where two factors were involved in this experiment, the first factor included the 4 tillage systems, which are conventional tillage (CT), reduced/minimal tillage (RT), conservation tillage (C8) at 8 cm depth and conservation tillage (C4) at 4 cm depth. The second factor included 4 fertilization treatments which are Manure 6m³/dunum (M₆m³), Manure 3m³/dunum + 6.25kg/dunum TSP + 6.25 kg/dunum AS (M₃m³/TSP₆₂₅kg/AS₆₂₅kg), Manure 3m³/dunum +12.5 kg/dunum TSP (M₃m³/TSP₁₂₅kg) and Manure 3m³/dunum +12.5 kg/dunum AS (M₃m³/AS₁₂₅kg).

5.4. Results:

Results revealed statistically significant differences within the examined tillage’s (CT, RT, C8 and C4) and fertilization types (M₃m³/TSP₆₂₅kg/AS₆₂₅kg, M₃m³/TSP₁₂₅kg and M₃m³/AS₁₂₅kg) as well as their interactions for the three yield components including total yield, grain yield and straw yield (Table 5.1). Moreover, a large effect sizes (η²) were indicated by both treatments and their interactions as well, however the greatest yield parameters were mainly related to tillage interventions rather than the assessed fertilizers (Table 5.1).

Table 5.1. Analysis of variance of yield parameters by different fertilization and tillage practices

<table>
<thead>
<tr>
<th>Factorial analysis</th>
<th>Sources of variation</th>
<th>Total yield kg/dunum</th>
<th>Grain yield kg/dunum</th>
<th>Straw yield kg/dunum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DF</td>
<td>F</td>
<td>Sig</td>
<td>η²</td>
</tr>
<tr>
<td>Tillage (a)</td>
<td>3</td>
<td>79.83</td>
<td>0.00*</td>
<td>0.857</td>
</tr>
<tr>
<td>Fertilizers (b)</td>
<td>4</td>
<td>9.37</td>
<td>0.00*</td>
<td>0.484</td>
</tr>
<tr>
<td>Interaction (a X b)</td>
<td>12</td>
<td>2.95</td>
<td>0.01*</td>
<td>0.470</td>
</tr>
</tbody>
</table>

Regarding the morphological parameters, tillers and stem length variables were significantly affected by the treatments and their interactions (Table 5.2). In addition, significant variations were also observed for spike length, spike length without awns and number of grains per spike due to the tillage and fertilization treatments, but there
were no significant differences due to their interactions (p-value > 0.05). Hereafter, the effect sizes demonstrated the highest values with tillage treatments for the tillers, stem length and spike length. Meanwhile fertilization effect size presented the highest effect with spike length without awns as well as number of grains per spike variables (Table 5.2).

Table 5.2. Analysis of variance of morphological parameters by different fertilization and tillage practices.

<table>
<thead>
<tr>
<th>Factorial analysis</th>
<th>Sources of variation</th>
<th>Tillage (a)</th>
<th>Fertilizers (b)</th>
<th>Interaction (a X b)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DF</td>
<td>3</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Tillers</td>
<td>F</td>
<td>55.88</td>
<td>25.75</td>
<td>6.65</td>
</tr>
<tr>
<td></td>
<td>Sig</td>
<td>0.00*</td>
<td>0.00*</td>
<td>0.00*</td>
</tr>
<tr>
<td></td>
<td>η²</td>
<td>0.81</td>
<td>0.72</td>
<td>0.67</td>
</tr>
<tr>
<td>Stem length</td>
<td>F</td>
<td>43.91</td>
<td>29.2</td>
<td>2.72</td>
</tr>
<tr>
<td></td>
<td>Sig</td>
<td>0.00*</td>
<td>0.00*</td>
<td>0.01*</td>
</tr>
<tr>
<td></td>
<td>η²</td>
<td>0.77</td>
<td>0.75</td>
<td>0.45</td>
</tr>
<tr>
<td>spike length</td>
<td>F</td>
<td>6.77</td>
<td>3.88</td>
<td>1.23</td>
</tr>
<tr>
<td></td>
<td>Sig</td>
<td>0.001*</td>
<td>0.009*</td>
<td>0.295</td>
</tr>
<tr>
<td></td>
<td>η²</td>
<td>0.34</td>
<td>0.28</td>
<td>0.27</td>
</tr>
<tr>
<td>Length of spike-awns</td>
<td>F</td>
<td>11.01</td>
<td>22.53</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>Sig</td>
<td>0.000**</td>
<td>0.000**</td>
<td>0.631</td>
</tr>
<tr>
<td></td>
<td>η²</td>
<td>0.45</td>
<td>0.69</td>
<td>0.2</td>
</tr>
<tr>
<td>No. grains/spike</td>
<td>F</td>
<td>7.7</td>
<td>8.75</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>Sig</td>
<td>0.000*</td>
<td>0.000*</td>
<td>0.908</td>
</tr>
<tr>
<td></td>
<td>η²</td>
<td>0.37</td>
<td>0.47</td>
<td>0.13</td>
</tr>
</tbody>
</table>

In general, RT and CT showed significantly higher wheat yield components than C4 and C8 respectively; however, RT exhibited the highest production values among tillage types and fertilizers treatments as well as their interactions (Table 4.3).

For total production variable (Table 4.3.1), RT exhibited significantly higher total wheat production over the other tillage types followed insignificantly by the CT. Meanwhile, no significant production values (narrow range between 1050 to 1133 kg/dunum) were observed among the examined fertilizers types in combination with RT.
Also, grain production was significantly affected by the tested practices (Table 4.3.2), where the reduced tillage presented the highest grain production among all the other treatments and almost 60% higher grain yield compared to the CT that was insignificantly followed the RT, while the lowest values were for the C4 and C8 respectively. Besides, there were insignificant variation among the fertilization treatments over the tillage treatments, where generally the M<sub>6m</sub><sup>3</sup> revealed the highest values over the other fertilization treatments and the highest value was recorded for RT×M<sub>6m</sub><sup>3</sup> (234 kg/dunum).

Furthermore, straw yield varied significantly among the tillage treatments over the fertilization treatments, in which the RT presented the highest straw value followed insignificantly by CT, however, the highest value were recorded for RT×M<sub>6m</sub><sup>3</sup>/TSP<sub>12.5</sub> (1028 kg/dunum) followed by RT× M<sub>3m</sub><sup>3</sup>/TSP<sub>12.5</sub> (1000 kg/dunum). Moreover, the C4 and C8 and their interactions with the tested fertilizers were also revealed the lowest straw production values. Hereafter, the fertilization treatments showed insignificant variation over the tillage treatments. Regarding the fertilization treatments over the tillage treatments, there were insignificant variations. However, the M<sub>6m</sub><sup>3</sup> treatment presented the highest value (628.25 kg/dunum) followed by M<sub>3m</sub><sup>3</sup>/TSP<sub>12.5</sub> (566.5 kg/dunum) (Table 5.3.3).

### Table 5.3. Comparison of means of yield parameters due to tillage and fertilizer interaction effect.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Tillage systems</th>
<th>(Fertilizers)</th>
<th>Av.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Control</td>
<td>M&lt;sub&gt;6m&lt;/sub&gt;&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Total yield (kg/dunum)</strong></td>
<td>CT</td>
<td>475 ±4b</td>
<td>1185±130a</td>
</tr>
<tr>
<td></td>
<td>RT</td>
<td>639 ±42b</td>
<td>1105±198a</td>
</tr>
<tr>
<td></td>
<td>C8</td>
<td>68 ±21c</td>
<td>271 ±63a</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>184 ±31a</td>
<td>408 ±96a</td>
</tr>
<tr>
<td></td>
<td>Av.</td>
<td>341.50 ±204a</td>
<td>742.25 ±467a</td>
</tr>
<tr>
<td><strong>Grain yield (kg/dunum)</strong></td>
<td>CT</td>
<td>65 ±1ab</td>
<td>157 ±27a</td>
</tr>
<tr>
<td></td>
<td>RT</td>
<td>54 ±4d</td>
<td>234 ±30a</td>
</tr>
<tr>
<td></td>
<td>C8</td>
<td>9 ±3a</td>
<td>27 ±4a</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>15 ±2a</td>
<td>39 ±12a</td>
</tr>
<tr>
<td></td>
<td>Av.</td>
<td>35.75 ±26a</td>
<td>114.25 ±95a</td>
</tr>
<tr>
<td><strong>Straw yield (kg/dunum)</strong></td>
<td>CT</td>
<td>410 ±5a</td>
<td>1028±105a</td>
</tr>
<tr>
<td></td>
<td>RT</td>
<td>584 ±40b</td>
<td>871 ±168a</td>
</tr>
</tbody>
</table>
In reference to the morphological traits; results exhibited significant highest values for tillering variable for the RT over the other tillage practices, furthermore its interactions with the examined fertilizers were also revealed significantly highest values in which the maximum tillering value was observed in RT×M₆₃ (4.10) followed by RT× M₃₃/TSP₁₂.₅kg (Table 5.4.1). Similar trends go also with RT and stem length trait, however its highest values were recorded for RT× M₃₃/TSP₁₂.₅kg and CT× M₆₃ (90 cm) (Table 5.4.2).

Concerning the spike length, RT exhibited significant higher values over the other evaluated tillage practices and examined fertilizers except with M₃₃/TSP₆.₂₅kg/AS₆.₂₅kg mixed fertilizer which showed slightly lower than CT. Here, the highest spike length was registered for RT×M₃₃/AS₁₂.₅kg (14.99 cm) followed by RT× M₆₃ (14.75 cm) (Table 5.4.3).

Regarding the spike length without awns trait, RT revealed significantly the highest values (6.08 cm) comparing to the other tillage treatments followed insignificantly by CT (5.40 cm), however the significant differences were observed between the fertilizer’s types, where the M₃₃/TSP₁₂.₅kg presented significantly the highest value followed significantly by M₆₃ (Table 5.4.4). According to the number of seeds per spike variable, RT recorded significant higher values over the other tillage treatments. Also, the examined fertilizers revealed insignificant variation among each other, but the control was significantly lower than all of them (Table 5.4.5). Furthermore, the highest number of seeds per spike was recorded for RT× M₃₃/AS₁₂.₅kg and RT× M₃₃/TSP₆.₂₅kg/AS₆.₂₅kg by 39.13 and 39.10 respectively.

<table>
<thead>
<tr>
<th>(kg/dunum)</th>
<th>C8</th>
<th>C4</th>
<th>Av.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>59 ±21a</td>
<td>169 ±31a</td>
<td>305.50 ±218a</td>
</tr>
<tr>
<td></td>
<td>244 ±65a</td>
<td>370 ±83b</td>
<td>628.25 ±382a</td>
</tr>
<tr>
<td></td>
<td>207 ±21a</td>
<td>397 ±98a</td>
<td>529.50 ±304a</td>
</tr>
<tr>
<td></td>
<td>176 ±96a</td>
<td>145 ±10b</td>
<td>566.50 ±469a</td>
</tr>
<tr>
<td></td>
<td>136 ±21a</td>
<td>269 ±48ab</td>
<td>460.00 ±331a</td>
</tr>
<tr>
<td></td>
<td>164.4 ±106b</td>
<td>270 ±140b</td>
<td>460.00 ±331a</td>
</tr>
</tbody>
</table>

- Comparison of means using one-way ANOVA and LSD.
- Different letters within row indicate a significant difference at the level 5%, the value represent means ± SE
- Conventional tillage (CT), Reduced tillage (RT), Conservation tillage at 8cm depth (C8), Conservation tillage at 4cm depth (C4).
- Manure (M), Tri superphosphate (TSP), Ammonium sulfate (AS).
- Manure 6m/dunum (M₆₃), Manure 3m/dunum + 6.25kg/dunum TSP + 6.25 kg/dunum AS (M₃₃/TSP₆.₂₅kg/AS₆.₂₅kg), Manure 3m/dunum +12.5 kg/dunum TSP (M₃₃/TSP₁₂.₅kg), Manure 3m/dunum +12.5 kg/dunum AS (M₃₃/AS₁₂.₅kg).

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Table 5.4. Comparison of means of morphological parameters due to tillage and fertilizer interaction effect.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Tillage systems</th>
<th>(Fertilization treatments)</th>
<th>Av.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Control</td>
<td>M₀现代社会</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>M₀现代社会³</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Av.</td>
</tr>
</tbody>
</table>

| Table 5.4.1. Tillers (cm) | CT                 | 2.00±0.29a                  | 3.50±0.42a                  | 1.60±0.15a                  | 3.60±0.30a                  | 2.00±0.06a                  | 2.58±0.9ab                  |
|                          | RT                 | 2.00±0.06c                  | 4.10±0.29a                  | 3.13±0.20b                  | 4.07±0.15a                  | 3.87±0.39ab                  | 3.43±0.9a                   |
|                          | C8                 | 1.45±0.03a                  | 1.83±0.15a                  | 1.80±0.10a                  | 1.33±0.07a                  | 1.90±0.23a                  | 1.66±0.4bc                  |
|                          | C4                 | 1.20±0.06a                  | 1.90±0.10a                  | 1.60±0.20a                  | 3.60±0.53a                  | 1.53±0.12a                  | 1.97±0.9c                   |
|                          | Av.                | 1.66±0.4b                  | 2.83±1.1ab                  | 2.03±0.7b                  | 3.15±1.2a                  | 2.38±1ab                    |                           |

| Table 5.4.2. Stem length (cm) | CT                 | 64±2.65c                   | 90±1.55a                   | 75±2.13b                   | 87 ±4.48a                  | 71 ±3.30bc                  | 77.4±11b                   |
|                          | RT                 | 74±1.63b                   | 86±2.13a                   | 88±1.21a                   | 90±3.22a                   | 86±1.69a                   | 84.8±7a                    |
|                          | C8                 | 47±1.69b                   | 74±4.31a                   | 66±5.27ab                  | 64±0.12ab                  | 64±2.39ab                  | 63.10fcd                  |
|                          | C4                 | 54±1.72b                   | 70±3.62ab                  | 72±4.14ab                  | 85±6.70a                   | 64±2.50ab                  | 69±12c                    |
|                          | Av.                | 59.75±1.1b                 | 80±10a                     | 75.25±10a                  | 81.5±13a                   | 71.25±10a                  |                           |

| Table 5.4.3. Spike length (cm) | CT                 | 12.45±0.17b                | 13.86±0.29ab               | 14.47±0.35a                | 14.19±0.55ab               | 13.04±0.13ab               | 13.60±0.9b                 |
|                          | RT                 | 14.34±0.66a                | 14.75±0.38a                | 13.94±0.12a                | 14.44±0.73a                | 14.99±0.38a                | 14.49±0.8a                |
|                          | C8                 | 12.64±1.63a                | 13.81±0.50a                | 13.95±0.22a                | 13.48±0.42a                | 13.47±0.55a                | 13.47±0.9b                |
|                          | C4                 | 12.75±0.17b                | 13.82±0.37ab               | 13.29±0.06ab               | 13.92±0.25a                | 13.61±0.58ab               | 13.48±0.7b                |
|                          | Av.                | 13.05±1b                   | 14.06±0.7a                 | 13.91±0.5a                 | 14.01±0.9a                 | 13.78±1a                   |                           |

| Table 5.4.4. Spike length without awns (cm) | CT                 | 4.21±0.3a                  | 6.05±0.32ab                | 5.21±0.28ab                | 6.26±0.14a                 | 5.29±0.21ab                | 5.40±0.8ab                 |
|                          | RT                 | 5.29±0.30b                 | 6.38±0.15a                 | 6.06±0.16a                 | 6.29±0.17a                 | 6.37±0.04a                 | 6.08±0.5a                  |
|                          | C8                 | 4.09±0.42b                 | 5.81±0.22a                 | 5.10±0.32ab                | 5.76±0.45a                 | 5.18±0.33ab                | 5.19±0.8b                  |
|                          | C4                 | 4.09±0.14c                 | 5.54±0.22ab                | 5.18±0.46b                 | 6.26±0.20a                 | 4.95±0.35bc                | 5.20±0.9b                  |
|                          | Av.                | 4.42±0.7d                  | 5.95±0.5b                  | 5.39±0.6c                  | 6.14±0.5a                  | 5.45±0.7c                  |                           |

| Table 5.4.5. Number of grains per Spike | CT                 | 22.33±2.2b                 | 33.13±3.17ab               | 28.87±1.01a                | 31.57±2.83a                | 32.60±1.75a                | 29.7±5b                    |
|                          | RT                 | 29.73±2.2a                 | 35.47±2.94a                | 39.10±1.39a                | 34.80±6.38a                | 39.13±1.65a                | 35.65±6a                  |
|                          | C8                 | 19.87±2.8b                 | 34.57±2.02ab               | 28.93±2.56a                | 30.23±0.14a                | 30.33±3.11a                | 28.79±7b                  |
|                          | C4                 | 19.83±1.8b                 | 31.37±1.07a                | 29.23±4.07a                | 30.30±3.29a                | 27.27±2.49ab               | 27.6±6b                    |
|                          | Av.                | 22.94±5b                   | 33.64±4a                   | 31.53±6a                   | 31.73±7a                   | 32.33±6a                   |                           |

5.5. Discussion:

Drought stress as the main aspect of climate change is the key limiting factor for any crop growth, development and production. Generally, drought resulted in crop water deficit which mainly arise from insufficient or uneven precipitation and accordingly shortage of soil moisture (Mar et al., 2018 and Imadi et al., 2019). Indeed, drought
threats our existence with serious consequences like famine and food insecurity (Senay et al., 2015).

5.5.1. Climate:

The crucial indicators for farmers and researchers to anticipate the growing season are rainfall and temperature (Maina et al., 2020). Despite the low precipitation, the irregular rainfall distribution and erratic precipitation patterns also cause substantial negative influence on crops productivity (Mar et al., 2018). In fact, light precipitation usually wet the soil surface which might not reach the sowing depth to activate seeds germination (Gesch et al., 2016), resulting thereby in low crop production. In case of wheat, its growth and development is considered as a stage-dependent requirement crop (Kesho et al., 2020), where the greatest wheat development occur under deep-root water uptake from a usual depth of 20-50 cm. Accordingly most of light rain evaporates due to the effect of atmospheric and soil temperature (Yang et al., 2018). Furthermore, temperature accelerates the evapotranspiration and reduces the water use efficiency (Gesch et al., 2016). Here, the harsh conditions including low precipitation and the high average temperature (Fig. 3.2+4) which characterize the region might explain the general significant low production in comparison to the world average wheat production. In addition, rainfall is not regularly distributed throughout the winter season, but rather the massive majority comes during short and intense periods of time (Fig. 3.2), which further worsens the problem of water availability for crop production (Basheer-Salimia and Ward, 2014), and increasing soil erosion as a result of water runoff (Safi and Mohammad, 2019) and nutrients leaching (Huang et al., 2020). For that, efforts have been made to mitigate drought impact (Eludoyin et al., 2017).

5.5.2. Production indicators:

The efficiency of the tillage practices as a tool to mitigate drought effect, improve soil properties (mainly soil moisture, nutrients uptake, soil organic matter), and increase wheat production under rain fed conditions has been documented by many researchers (Lopez-Garrido et al., 2014; Stanek-Tarkowska et al., 2018; Hofmeijer et al., 2019, Singh et al., 2020).

In this study, the higher values of CT compared to the RT in some yield and morphological parameters could be explained by the effect of the initial transition from the conventional to the conservation practices (Peigné et al., 2014), that characterized
with higher soil surface layer compaction, greater weeds density (Abdalla et al., 2013), and higher bulk density which occurred while the soil recover humus content, structural constancy and pore spaces, resulting thereby in lower yield (Pittelkow et al, 2015). Indeed this is a short term study (one season) and is definitely not sufficient to reveal the impact of the examined tillage and fertilization practices, but it gives indicators for the possible effects of these practices that need more investigation on longer term. Nevertheless, the superiority of RT in most yield parameters could be related to the positive effect of the reduced tillage mainly on soil properties, in which RT found to improve soil physical and biochemical properties more than CT in a five years experiment, resulting thereby in higher wheat yield (Lopez-Garrido et al. 2014). Furthermore, RT increases soil moisture content which resulted from lower bulk density (Gholami et al., 2014), better water infiltration and soil conservation capacity (Acar et al., 2017), thus enhancing root number (Volkmar, 1996) as well as root development and water absorption (Gangwar et al., 2019), consequently, increasing the fertilization impact on yield parameters. This indeed explains the significant variation between the unfertilized and the fertilized treatments (Abedi et al., 2010).

Other approach of the effects of RT practice on wheat production is also revealed via increasing the mycorrhizae spore's number and total organic carbon which shown better soil quality in comparison to CT (Celik et al., 2011). Furthermore, Ghaley et al. (2018) attributed the highest wheat production to the high soil organic carbon that conserves more moisture and encourages nutrients uptake. Indeed, the Arbuscular mycorrhizal fungi mainly improve nitrogen (N) and phosphorus (P) uptake and accordingly increasing wheat yield (Thirkell et al. 2019). Also, the results of the same study indicated that wheat response to Arbuscular mycorrhizae is affected by wheat genotypes. Here, our tested genotype (var. Yellow Heteya) could be more responsive to Arbuscular mycorrhizae and may be one of the possible explanations of the exhibited higher yield values comparing to a previous study on the performance of six Palestinian wheat genotypes (Basheer-Salimia and Atawne, 2014).

Regarding the fertilization practices, the highest production values presented by M6m³ usage over the other fertilization treatments could be elucidated to the improvement in soil properties and nutrients availability that resulted from using the organic manure. In fact, organic manure increases water holding capacity, aggregates stability and nutrients uptake (Rasul et al., 2015). Moreover, organic manure reduces the soil pH and provides more carbon for the phosphate solubilizing bacteria that results more P availability...
(Nosratabad et al., 2017). In addition, it improves soil enzymatic activities (e.g. alkaline phosphatases, urease, dehydrogenase, β-glucosidasen) that indicate better soil quality and thus increase wheat yield (Liu et al., 2010). On the other hand, the highest total yield for CT× M$^{3}_{3m}$ could be explained by the effect of the conventional tillage (twice tilled) that accelerates the manure decomposition and nutrients release compared to the conservation systems especially in the initial transformation stage from the conventional system towards the conservative system (Lupwayi et al., 2004; Houben et al., 2018).

Also, the exhibited higher RT and CT values in combinations with M$^{3}_{3m}$/TSP$_{12.5kg}$ (1133 kg and 1068kg respectively) could be related to the higher P input and its high availability in the soil as a result of its enhancement with tillage practices (Nosratabad et al., 2017; Singh et al., 2020).

However, the lower yield parameters of M$^{3}_{3m}$/TSP$_{6.25kg}$/AS$_{6.25kg}$ comparing to the M$^{3}_{3m}$/TSP$_{12.5kg}$ might be related to the lower phosphorus and high nitrogen content in such mixed-fertilizers (Haile et al., 2012; Nosratabad et al., 2017). According to Ghaley et al. (2018) it was found that the more the N fertilization increased, the less the effect of soil organic carbon and consequently the total wheat production. This remarkable decline of the nitrogen impact could be interpreted by the nitrogen immobilization that resulted from the higher C:N ratio (Stevenson and Cole, 1999; Pan et al., 2017). This result complies with our results, where RT× M$^{3}_{3m}$/AS$_{12.5kg}$ and CT× M$^{3}_{3m}$/AS$_{12.5kg}$ revealed the lowest total yield comparing to the other RT and CT combinations.

Contrary to these findings, the conservation tillage (C8 and C4 and their combination with fertilizers) revealed the lowest production values. These low values could be related to the low seeds germination rate resulted from the shallower sowing depth that is highly affected by the atmospheric conditions especially moisture and temperature (Pittelkow et al., 2015), in which the lack of soil mulch (straw mulch) exacerbates the effect of soil moisture evaporation and temperature fluctuation on seeds germination (Büchi et al., 2018). Also, the low wheat density which resulted from the low seeds germination could explain this low production (Dai et al., 2014). Moreover, the low wheat density in C8 and C4 tillage systems gives way to higher weed density that compete with wheat and reduces the yield (Olsen et al., 2005). Duchemin et al. (2006) found that lower wheat vegetation coverage induces soil water lose, which increase the drought effect on wheat.

Another possible explanation for the significant lower wheat production of C8 and C4 tillage systems compared to the RT and CT is the effect of rain pattern in the study area.
which is subjected to splash erosion due to its shallow tillage’s, in addition to the low vegetation cover characteristics (Ma et al., 2014). Indeed, such erosion that resulted from the intensive shadow rain increases water loss and causes nutrients leaching (Safi and Mohammad, 2019), resulting thereby in low wheat production in such tillage practices. Besides, wheat canopy characteristics (e.g. cover, structure … etc.) may influence the wheat yield by modifying the temperature, respiration and evaporation rates, for example canopy temperature became more than the air temperature under drought stress (Neukam et al., 2016) and this probably made C8 and C4 tillage systems that have low canopy cover and less water retention more affected by the heat stress.

Concerning the morphological characteristics, the highest presented values with RT practice and its combinations with different fertilizers might be related to the tillage effects and its effects on moisture and soil properties. For example, the superiority of RT in tillering as an important morphological trait could be related to the tillage effect (Leghari et al., 2015; Ali et al., 2016) and its positive influence on soil moisture and soil properties (Gholami et al., 2014). Also, manure, nitrogenous and phosphorus fertilizers found to improve tillers emergence, increase tillering and leaf areas as well as photosynthesis (Fioreze et al., 2012; Khursheed and Mohammad, 2015; Ali et al., 2020). Contrary to these findings, significant lower tillering values revealed by C8 and C4 tillage systems which might be explained by the higher soil compaction implications (Wu et al., 2018).

Regarding the significant high stem length values, it might be also related to the tillage effect and nitrogenous fertilizers (Kayan et al., 2018), phosphorus fertilizers (Fioreze et al., 2012), manure (Ali et al., 2020) and the combination between the organic and inorganic fertilizers (Abbas et al., 2012).

Similar positive trend goes also with the spike characteristics, which also positively influenced by tillage system (Ali et al., 2016), fertilization treatments (Abbas et al., 2012), as well as soil moisture content and tillering that positively affected spike characteristics (Yang et al., 2020). Indeed, the highest stem and spike length values were reflected on the total yield (Imran et al., 2013). Khorami et al., (2018) found insignificant effect for the tillage system and number of grains per spike. To the contrary of our results, Ali et al. (2016) reported higher values for spike length and number of kernels per spike for the conservation system over the conventional. This contradictory could be related to the soil characteristics, row spacing and the absence of water stress in that experiment site; likewise, Imran et al. (2013) indicated higher results
for RT comparing to CT, where the highest number of fertile tillers in conservation tillage (419 tiller/m²) while conventional tillage presented the lowest value (405 tiller/m²). Also, in the same study, the reduced tillage presented higher plant height over the conventional tillage (96.38 cm and 95.40 cm respectively) and higher number of grains per spike (RT 51.4 grains per spike and CT 50.5 grains per spike).

5.6. Conclusions:

Reduced tillage (RT) has proven its high efficiency in increasing wheat productivity. Furthermore, this practice is less cost, less efforts and more applicable than CT (twice-tilled). Compatibly, the manure treatment (\(M_3m^3\)) is highly recommended for sustainable wheat production and to increase the grain yield due to its availability and its positive impact on soil properties and also limiting the usage of inorganic fertilizers and its bad implications on soil and underground water as well. Moreover, \(M_3m^3/TSP_{12.5kg}\) was the best choice to increase the straw yield. Finally, further researches are needed toward evaluating the effects of conservation tillage and its combinations with the organic fertilizers at a longer period.
CHAPTER VI: General Conclusions

- Reduced tillage (RT) has proven its high efficiency in improving soil properties in semi-arid conditions, and consequently increasing wheat productivity. Indeed, this practice is less cost, less efforts and more applicable than CT (twice-tilled).
- Decomposed manure (M_{fm}^{3}) is highly recommended for sustainable wheat production and to increase grain yield due to its availability and its positive impact on soil properties and also limiting the usage of inorganic fertilizers and its bad implications on soil and underground water as well.
- Combination of organic and inorganic fertilizers could increase the nutrients use efficiency, roots uptake and productivity; where M_{fm}^{3}/TSP_{12.5kg} was the best choice to increase the straw yield.
- The winter wheat (var. Yellow Heteya) seems to be more adaptable and tolerable for such climatic conditions and it could be more productive when treated with suitable tillage and fertilization practices.
- The conservation tillage systems are less efficient at the initial transformation stage from conventional to conservation, but it is a promising long-term approach. Therefore, further researches are needed toward evaluating the effects of conservation tillage and its combinations with the organic and inorganic fertilizers on wheat in arid and semi-arid areas at a longer period.
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الملخص باللغة العربية

مواءمة الممارسات الزراعية للتخفيف من آثار الجفاف على إنتاج القمح في فلسطين

يعتبر القمح (Triticum aestivum L.) ركيزة أساسية من ركائز الأمن الغذائي العالمي بما في ذلك الشرق الأوسط. هذا ويتزايد الطلب على القمح من سنة لأخرى ويتزايد معه بالتالي مجمل الإنتاج العالمي، إلا أنه يتناقص في بعض الدول نتيجة لعدد من العوامل أهمها الجفاف وسوء التوزيع المطرى وارتفاع درجات الحرارة والعوامل المرتبطة بالزراعة والجراد والصراعات البشرية.

في فلسطين، تتناقص إنتاج القمح بشكل مطرد وذلك لعدة عوامل والتي تشمل الممارسات الزراعية الخاطئة وتدهور الأصناف والاهتمام الحيوي وكذلك التغير المناخي وتداعياته على وجه الخصوص. حيث يعتبر الجفاف وارتفاع درجات الحرارة من أهم العوامل الحاسمة لارتفاع المحاصيل الحقلية في الشرق الأوسط عموماً بما في ذلك فلسطين. هذا ويتزايد العديد من الأساليب والوسائل الزراعية المتاحة للتخفيف من أثر التغير المناخي وبالتالي زيادة إنتاج القمح والتي أهمها مواد الزراعة المحافظة والتي تثبت أنها الأكثر قابلة للتطبيق نظرًا لسهولة إجرائها وقلة تكاليفها وإمكانية تنفيذها وتحقيقها ليس فقط من خلال العلماء والباحثين بل عن طريق المزارعين أيضاً الذين هم حجر الأساس في تغيير وتعدي ومعايير الممارسات الزراعية المختلفة على مدى التاريخ البشري.

تهدف هذه الدراسة إلى تقييم أثر ممارسات الحراثة وتعدي مختلفة على صفات القمح الشكلية ومكونات الإنتاج الخاصة بالقمح، وتحديداً صنف الهفت الصفراء الذي زرع بعلماً. وتحقيق ذلك تم اختيار منطقة سفوح محافظة بيت لحم الشرقية والمصنفة كمناطق جافة إلى شبه جافة والتي تعاني مؤخراً من ظاهرة الجفاف وذلك في الموسم الزراعي 2018/2019.

هذا وتم تنفيذ التجربتين، حيث شملت التجربة الأولى على تقييم أربع أنظمة حراثة هي: الحراثة التقليدية (CT) والحراثة الحافظة والتي استخدم فيها ثلاثة أنظمة هي الحراثة المختصة (RT) والحراثة الحافظة على عمق 4 سم (C4) والحراثة الحافظة على عمق 8 سم (C8). هذا وتم توزيع المكررات ضمن تصميم القطاعات العشوائي (RBD)، أما التحقيق الثاني، فكانت تجربة عاملين وتشمل تصنيع القطاعات العشوائية (FRBD)، حيث تم دمج معاملات الحراثة مع معاملات التسميد التي شملت أنواعها وكميات ونسب مختلفة من زيل الأغنام وسوبر فوسفات الثلاثي وسلفات الأمونياك كما يلي: 6 كوب زيل أغنام/دونم، 3 كوب زيل أغنام + سوبر فوسفات ثلاثي 6.25 كغم/دونم + سلفات أمونياك 6.25 كغم/دونم، 3 كوب زيل أغنام + سوبر فوسفات ثلاثي 6.25 كغم/دونم + سلفات أمونياك 12.5 كغم/دونم.

أظهرت الدراسة وجود فروق معنوية بين المؤشرات المقصاة. حيث بنت النتائج أن الحراثة المختصرة أعطت وقوف معنوية الإنتاج الأعلى وطول الساق الأول بالإضافة إلى وجود المواصفات في السبلة بينها نظام الحراثة التقليدية. أما بالنسبة للجزء الثاني فقد توقفت الحراثة المختصرة عندما أضيف إليها زيل أغنام بمعدل 6
كوب للدونم في إنتاج البذور وعندما أضيف إلى الحراجة المختصرة 3 كوب زبل أغنام + سوبر فوسفات ثلاثي 12.5 كغم/دونم فقد أعطت أفضل إنتاج للقش.

بالإضافة إلى ذلك، فقد همت الحراجة المختصرة على ممارسات الحراج الأخرى في جانب المواصفات الشكلية للقمح، والتي تعد مؤشرًا مهمًا لاستجابة القمح للمعلقات المطبية وللدم تأقلمه مع ظروف الاجهاد. أيضاً فقد تبين في كلا الجزئين من التجربين أن الحراجة الحافظة على عمق 4 و8 سم قد أعطت أدنى النتائج، وحتى عند إضافة الأسمدة إليها.

تجدر الإشارة إلى أن بعض المؤشرات كانت نتائجها أعلى في الحراجة التقليدية منها في الحراجة المختصرة، إلا أن هذه الزيادة غير كبيرة لتفعيل المصاريف الحراج المتكرر. أما فيما يتعلق بالأسمدة، ففيما أظهرت معاملة زبل الأغنام بمعدل 6 كوب للدونم أعلى النتائج، متفوقة على كل معاملات التسميد الأخرى.

بالنسبة للانخفاض المعنوي الذي ظهر في نتائج الحراجة الحافظة، فقد يمكن تبريره بتأثير المرحلة الأولية للتحول من الأنظمة التقليدية إلى الأنظمة الحافظة، والذي يحتاج عادة إلى فترة من الزمن.

حققت الأغراض الزراعية الحافظة يتم الإبقاء على ما يقارب من 30% من مخلفات المحاصيل في الأرض، ولكن بسبب انحسار المناطق الرعوية الناتجة بسبب التغير المناخي والنزوح العمراني والقوة الاستعمارية، فإن رعاة الأغنام يضطرون لرعي مواشيهم في الحقول لتغذية هذه القطعان على مخلفات تلك المحاصيل.

لذلك فإنه يوصي بتوعية رعاة الأغنام بفوائد ترك مخلفات المحاصيل في الأرض والتي ينتج عنه من زيادة في الإنتاج.

إن هذه الدراسة -قصيرة المدى- ليست كافية ويشمل قطعية تقييم أثر معاملات الحراجة والتسمية على القمح، ولكنها تعطي مؤشرات لممارسات واعدة للتكييف مع تبعات التغير المناخي، مما يستدعي مزيدًا من البحث والدراسة على فترة أطول.