Hebron University

College of Graduate Studies and Academic Research

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

By:

Eyaas Mahmoud Abu-Rabada

Supervisor:

Prof. Dr. Rezq Basheer-Salimia

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

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

By:

Eyaas Mahmoud Abu-Rabada

This thesis was successfully defended and approved on June 17th, 2021

by:

Examination Committee:		**Signature**
Prof. Dr. Rezq Basheer –Salimia	Main Supervisor	
Dr. Tahseen Sayara	External examiner	
Prof. Dr. Ayed Salama	Internal examiner	

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.

TABLE OF CONTENTS

List of tables

List of figures

General abstract

Wheat (*Treticum 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 6m^3/dunum ($M_{6m}{}^3$); manure 3m^3/dunum+ TSP 6.25 kg/dunum+ AS 6.25 kg/dunum ($M_{3m}{}^3/TSP_{6.25kg}/AS_{6.25kg}$); manure 3m^3/dunum+ TSP 12.5 kg/dunum ($M_{3m}{}^3/TSP_{12.5kg}$) and manure 3m^3/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× M_{6m}^{3} in term of grain yield production and RT× $M_{3m}^{3}/TSP_{12.5kg}$ 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 (*Treticum aestivum* L.).

CHAPTER I: Literature Review

1.1. Wheat:

1.1.1. Wheat origin:

Wheat (*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 (*Triticum aestivum* ssp. aestivum) (Bálint *et al.*, 2000; Goncharov *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 *Triticum aestivum* L. which are commonly used for bread and Triticum durum that commonly used for spaghetti, pasta and macaroni (Uthayakumaran and Wrigley, 2017).

Table 1. 1. Wheat taxonomic hierarchy. http://plants.usda.gov

Kingdom	Plantae –plants, Planta, Vegetal, plants
Subkingdom	Viridiplantae – green plants
Infra-kingdom	Streptophyta – land plants
Super-division	Embryophyta
Division	Tracheophyta – vascular plants, tracheophytes
Subdivision	Spermatophytina – spermatophytes, seed plants, phanérogames

Class	Magnoliopsida
Super-order	Lilianae – monocots, monocotyledons, monocotylédones
Order	Poales
Family	Poaceae – grasses, graminées
Genus	Triticum L. – wheat
Species	*Triticum aestivum* L. – common wheat
Subspecies	*Triticum aestivum* ssp. aestivum L.

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℃, but temperature above 34℃ 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).

Code	Description	Code	Description	
0	Germination			
0.0	Dry seed	37	Flag leaf just visible	
0.1	Start of imbibition	38	Flag leaf ligule just visible	
0.2	Imbibition complete	4.0	Booting	
0.3	Radicle emerged from seed	41	Flag leaf sheath extending	
0.4	Coleoptile emerged from seed	43	Boots just visible swollen	
0.5	Leaf just at coleoptile tip	45	Boots swollen	
1.0	Seedling growth	47	Flag leaf sheath opening	
10	First leaf through coleoptile	49	First awns visible	
11	First leaf unfolded	5.0	Ear emergence	
12	2 leaf unfolded	51	First spikelet of ear just visible	
13	3 leaf unfolded	53	One-fourth of ear visible	
14	4 leaf unfolded	55	One-half of ear emerged	
15	5 leaf unfolded	57	Three-fourths of ear emerged	
16	6 leaf unfolded	59	Emergence of ear completed	
17	7 leaf unfolded	6.0	Flowering	
18	8 leaf unfolded	61	Beginning of flowering	
19	9 or more unfolded	65	Flowering half-way complete	
2.0	Tillering	69	Flowering complete	
20	Main shoot only	7.0	Milk development	
21	Main shoot and 1 tiller	71	Seed water ripe	
22	Main shoot and 2 tillers	73	Early milk	An increase in the s
23	Main shoot and 3 tillers	75	Medium milk	of the liquid endosp
24	Main shoot and 4 tillers	77	Late milk	notable when crushi
25	Main shoot and 5 tillers			the seed between fi
26	Main shoot and 6 tillers	8.0	Dough development	
				Fingernail impression n
27	Main shoot and 7 tillers	83	Early dough	held
28	Main shoot and 8 tillers	85	Soft dough	(Fingernail impression h
29	Main shoot and 9 or more tillers	87	Hard dough	head losing chlorophyll
3.0	Stem elongation	9.0	Ripening	
30	Pseudostem erection (winter cereals only)	91	Seed hard (difficult to divide by thumbnail)	
31	1st node detectable	92	Seed hard (can no longer be dented by thumbnail)	
32	2nd node detectable	93	Seed loosening in daytime	
33	3rd node detectable	94	Over-ripe; straw dead and collapsing	
34	4th node detectable	95	Seed dormant	
35	5th node detectable	96	Viable seed giving 50% germination	
36	6th node detectable	97	Seed no dormant	
37	Flag leaf just visible	98	Secondary dormancy induced	
39	Flag leaf ligule just visible	99	Secondary dormancy lost	

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.

#	Parameters	References	#	Parameters	References
1	Total yield	Thirkell *et al.* 2019	34	Leaf area	Ajlouni *et al.*, 2020
2	Grain yield	Zhang *et al.*, 2020	35	Leaf hairiness	Doroshkov *et al.*, 2011
3	Grain weight / plant	Farooq *et al.*, 2018	36	Trichome number and length	Pshenichnikova *et al.*, 2016
4	Straw yield	Zhang *et al.*, 2020	37	Leaf dry weight	Ajlouni *et al.*, 2020
5	Harvest index	Panozzo *et al.*, 2020	38	Stem length	Kayan *et al.*, 2018
6	Plant height	Jiang *et al.*, 2020	39	Stem strength	Karman *et al.*, 2018
7	awn shape and length	Yoshioka *et al.*, 2017	40	peduncle length	Farooq *et al.*, 2018
8	Spike length	Boussakouran *et al.*, 2019	41	Node and internode	Ghaffar *et al.*, 2017
9	Spike size	Panozzo *et al.*, 2020	42	Number of shoots	Djuric *et al.*, 2018
10	Spike weight	Chen *et al.*, 2019	43	Tillers number	Ali *et al.*, 2016
11	Spike area	Boussakouran *et al.*, 2019	44	Tillers fertility	Ye *et al.*, 2015
12	Spike Fertility	Tshikunde *et al.*, 2019	45	Root biomass	Zhang *et al.*, 2020
13	Spike compactness	Tshikunde *et al.*, 2019	46	Root length	Chen *et al.*, 2017
14	Number of spikes / m^2	Beral *et al.*, 2020	47	Root density	Wasson *et al.*, 2017
15	Number of grains / spikes	Khorami *et al.*, 2018	48	Root dry weight	Petrarulo *et al.*, 2014
16	Grain weight / spike	Ashfaq *et al.*, 2003	49	Root surface area	Petrarulo *et al.*, 2014
17	Number of kernels / spikelet's	Würschum *et al.*, 2018	50	Average root diameter	Petrarulo *et al.*, 2014
18	Number of spikes / plants	Panozzo *et al.*, 2020	51	Root volume	Petrarulo *et al.*, 2014
19	Number of spikelets / spikes	Djuric *et al.*, 2018	52	Number of root tips	Petrarulo *et al.*, 2014
20	spikelet arrangement	Wolde *et al.*, 2019	53	Shoot dry weight	Petrarulo *et al.*, 2014
21	Wight of 1000 grain	Gholami et al, (2014)	54	Canopy Temperature	Tshikunde *et al.*, 2019
22	Grain size	Beral *et al.*, 2020	55	Chlorophyll Content	Tshikunde *et al.*, 2019
23	Grain shape	Nuttall *et al.*, 2017	56	photosynthetic capacity	Tshikunde *et al.*, 2019
24	Grain hardness	Nuttall *et al.*, 2017	57	Water soluble carbohydrates	Tshikunde *et al.*, 2019
25	Grain N content	Nuttall *et al.*, 2017	58	Days to flowering	Tshikunde *et al.*, 2019
26	Grain starch content	Nuttall *et al.*, 2017	59	Days to maturity	Tshikunde *et al.*, 2019
27	Milling yield	Nuttall *et al.*, 2017	60	Membrane Thermostability	Cossani and Reynolds, 2012
28	Number of grains / m^2	Beral *et al.*, 2020	61	Wax/Glaucous	Cossani and Reynolds, 2012
29	Flag leaf length	Boussakouran *et al.*, 2019	62	Respiration	Cossani and Reynolds, 2012
30	Flag leaf width	Tshikunde *et al.*, 2019	63	Stay-Green	Cossani and Reynolds, 2012
31	Flag leaf area	Boussakouran *et al.*, 2019	64	Rapid Ground Cover and Canopy Structure	Cossani and Reynolds, 2012
32	Flag leaf angle	Tshikunde *et al.*, 2019	65	Photosynthesis/Photorespiration	Cossani and Reynolds, 2012
33	Green leaf area	Boussakouran *et al.*, 2019	66	Photoprotective Metabolites	Cossani and Reynolds, 2012

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 ^{o}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℃ 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℃ 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 (N_2O, CO_2 and CH_4) 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).

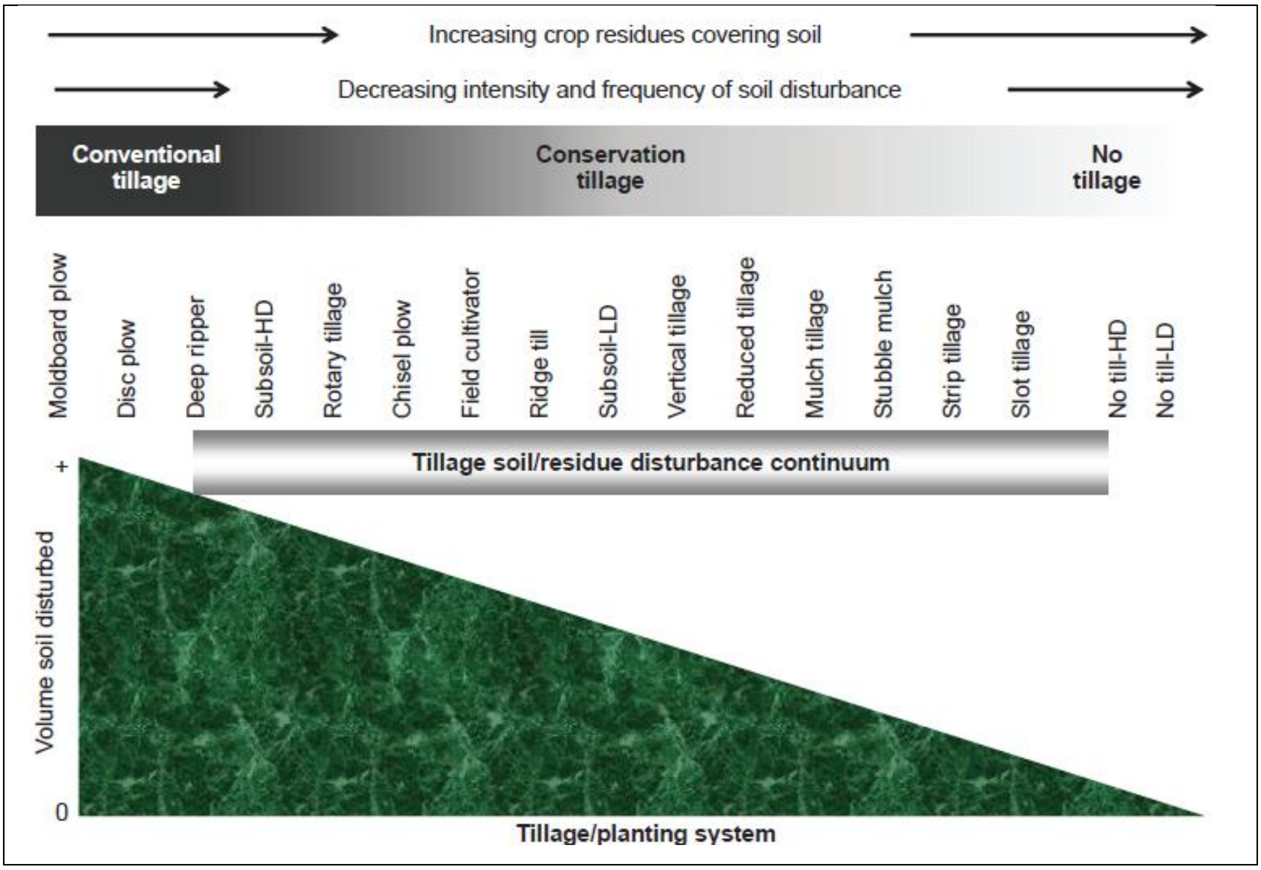

Fig. 1.1. Schematic diagram that categorizes the tillage systems according to soil disturbance "HD: high disturbance; LD: low disturbance", (Reicosky, 2015).

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 (Małecka *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, 2012), while Gangwar *et al.,* (2019) found that conventional tillage exceed the conservation tillage in term of grain yield. In other study, Małecka *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 and Asoodar, 2014). 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_2O 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, vermi-compost …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℃ and maximum temperature was registered in April 2019 with 22.2℃ (Fig. 3.4).

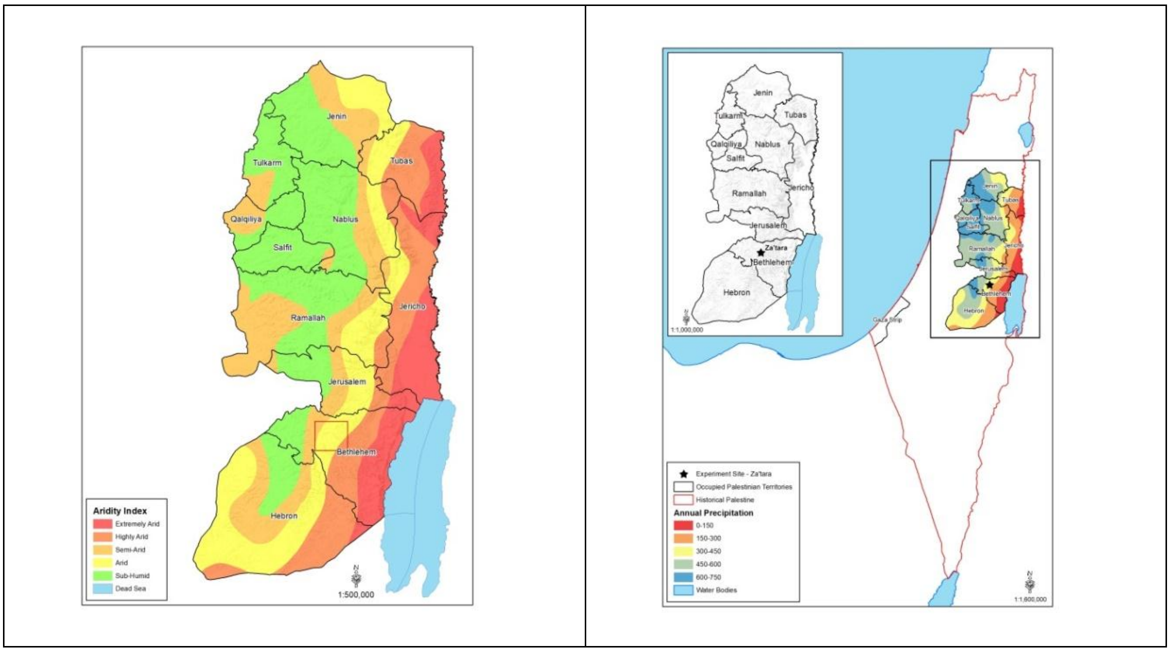

Fig. 3.1. Maps showed the aridity index of targeted study site (the left) and the average annual precipitation (the right).

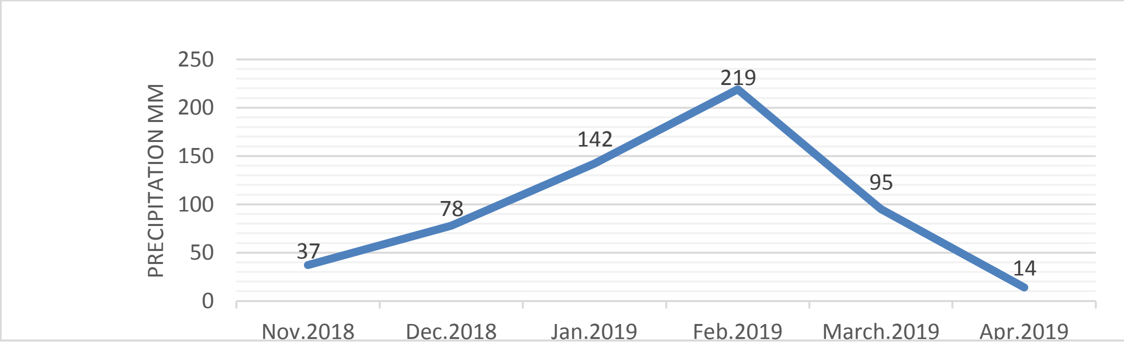

Fig. 3.2. Monthly precipitation (mm) in the experimental area during November 2018 – April 2019. (Source: Za'tara Secondary School rainfall monitoring station database).

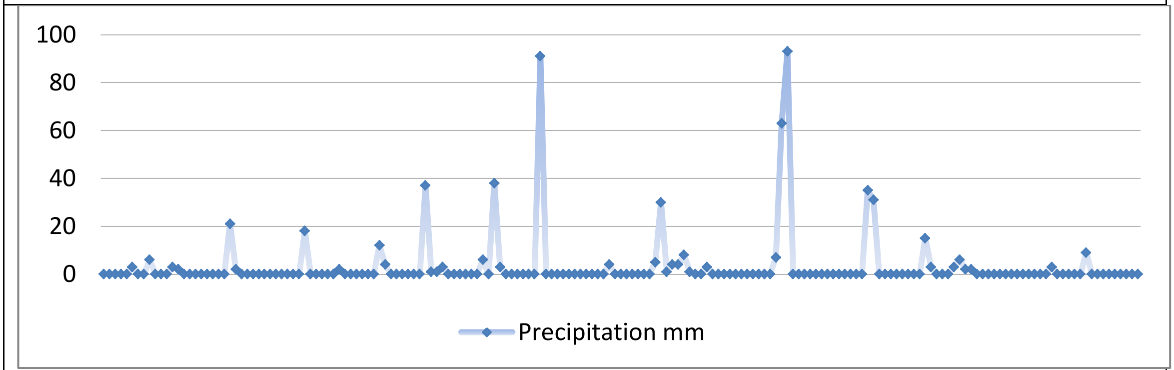

Fig. 3.3. Daily rain (mm) in the experiment area November 2018 – April 2019. (Source: Za'tara Secondary School rainfall monitoring station database).

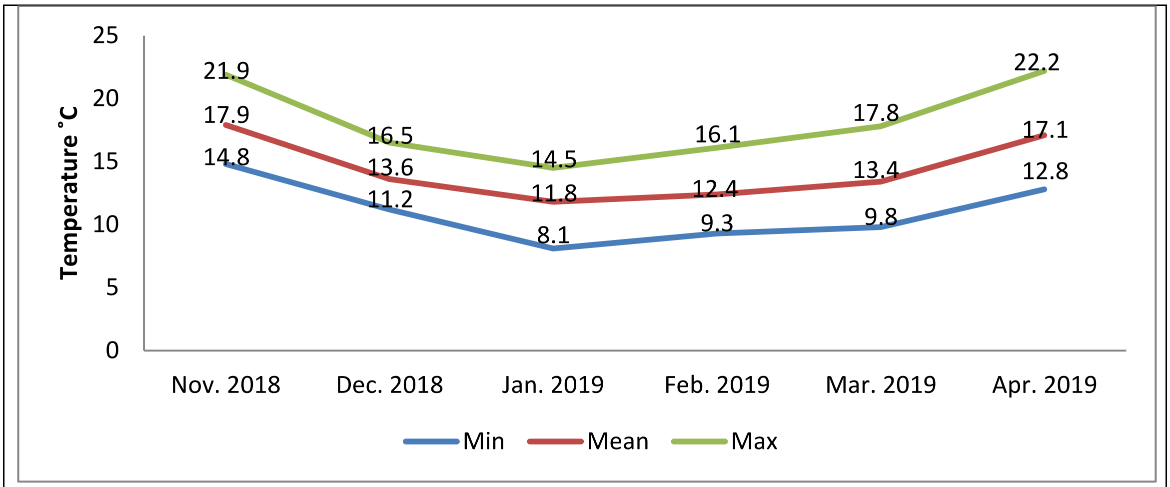

Fig. 3.4. Minimum, Maximum, and Mean monthly temperatures °C in the experiment area during November 2018 – April 2019. (Source: The Palestinian Astronomical Society database).

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, tri-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=1000m^2) for all treatments. While CT and RT sites were tilled by using sweep duck foot cultivator.

Fig. 3.5. Conservation tillage sowing machine.

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 shacking.

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.

CHAPTER IV: Adaptation of Tillage-Practices toward Mitigating Drought Effects on Wheat (*Triticum aestivum* L.) Production in Palestine.

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 4cm 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 worlds: *Treticum 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 threating 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).

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

*: Means within rows using different letters are differ significantly at the $P \leq 0.05$ 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).

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

*: Means within rows using different letters are differ significantly at the $P \leq 0.05$ 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 (Al-salimiyia, *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; Albaba, 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 CO_2 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 (*Treticum 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 6m^3/dunum ($M_{6m}{}^3$), manure 3m^3/dunum+ TSP 6.25 kg/dunum+ AS 6.25 kg/dunum ($M_{3m}{}^3$/$TSP_{6.25kg}$/$AS_{6.25kg}$), manure 3m^3/dunum+ TSP 12.5 kg/dunum ($M_{3m}{}^3$/$TSP_{12.5kg}$) and manure 3m^3/dunum+ AS 12.5 kg/dunum ($M_{3m}{}^3$/$AS_{12.5kg}$)) in addition to the control that was tilled without any fertilization treatments. Generally, our results revealed the superiority of the RT× $M_{6m}{}^3$ in term of grain yield production. On the other hands, RT× $M_{3m}{}^3$/$TSP_{12.5kg}$ 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 this 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 6m^3/dunum **($M_{6m}{}^3$)**, Manure 3m^3/dunum + 6.25kg/dunum TSP + 6.25 kg/dunum AS **($M_{3m}{}^3/TSP_{6.25kg}/AS_{6.25kg}$)**, Manure 3m^3/dunum +12.5 kg/dunum TSP **($M_{3m}{}^3/TSP_{12.5kg}$)** and Manure 3m^3/dunum +12.5 kg/dunum AS **($M_{3m}{}^3/AS_{12.5kg}$).**

5.4. Results:

Results revealed statistically significant differences within the examined tillage's (CT, RT, C8 and C4) and fertilization types ($M_{3m}{}^3$, $M_{3m}{}^3/TSP_{6.25kg}/AS_{6.25kg}$, $M_{3m}{}^3/TSP_{12.5kg}$ and $M_{3m}{}^3/AS_{12.5kg}$) 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 (η^2) 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

Factorial analysis		**Total yield kg/dunum**			**Grain yield kg/dunum**			**Straw yield kg/dunum**		
Sources of variation	DF	F	Sig	η^2	F	Sig	η^2	F	Sig	η^2
Tillage (a)	3	79.83	0.00*	0.857	56.24	0.00*	0.808	74.74	0.00*	0.849
Fertilizers (b)	4	9.37	0.00*	0.484	12.01	0.00*	0.546	8.16	0.00*	0.449
Interaction (a X b)	12	2.95	0.01*	0.470	3.39	0.00*	0.504	3.10	0.00*	0.482

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.

Factorial analysis	Sources of variation	Tillage (a)	Fertilizers (b)	Interaction (a X b)
	DF	3	4	12
Tillers	F	55.88	25.75	6.65
	Sig	0.00*	0.00*	0.00*
	η^2	0.81	0.72	0.67
Stem length	F	43.91	29.2	2.72
	Sig	0.00*	0.00*	0.01*
	η^2	0.77	0.75	0.45
spike length	F	6.77	3.88	1.23
	Sig	0.001*	0.009*	0.295
	η^2	0.34	0.28	0.27
Length of spike-awns	F	11.01	22.53	0.82
	Sig	0.000**	0.000**	0.631
	η^2	0.45	0.69	0.2
No. grains/spike	F	7.7	8.75	0.49
	Sig	0.000*	0.000*	0.908
	η^2	0.37	0.47	0.13

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_{6m}^3 revealed the highest values over the other fertilization treatments and the highest value was recorded for RT×M_{6m}^3 (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 CT×M_{6m}^3 (1028 kg/dunum) followed by RT× M_{3m}^3/$TSP_{12.5kg}$ (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_{6m}^3 treatment presented the highest value (628.25 kg/dunum) followed by M_{3m}^3/$TSP_{12.5kg}$ (566.5 kg/dunum) (Table 5.3.3).

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

Variables	Tillage systems	(Fertilizers)					Av.
		Control	M_{6m}^3	M_{3m}^3/$TSP_{6.25kg}$/$AS_{6.25kg}$	M_{3m}^3/$TSP_{12.5kg}$	M_{3m}^3/$AS_{12.5kg}$	
Table 5.3.1. Total yield (kg/dunum)	CT	475 ±4b	1185±130a	625 ±71b	1068 ±204a	525 ±68b	775.6 ±348a
	RT	639 ±42b	1105±198a	1105 ±73a	1133 ±25a	1050±180a	1006.4 ±291a
	C8	68 ±21c	271 ±63a	229 ±42a	149 ±22b	200 ±106a	183.4 ± 114b
	C4	184 ±31a	408 ±96a	451 ± 115a	160 ± 11a	287 ±46a	298 ±159b
	Av.	341.50 ±204a	742.25 ±467a	602.50 ±357a	627.50 ±518a	515.50 ±383a	
Table 5.3.2. Grain yield (kg/dunum)	CT	65 ±1ab	157 ±27a	66 ±8ab	83 ±38ab	50±1b	84.2 ±50a
	RT	54 ±4d	234 ±30a	151 ±15b	134 ±12bc	130 ±37bc	140.6 ±68a
	C8	9 ±3a	27 ±4a	21 ±6a	12 ±1a	23.33±9.90a	18.47 ±11b
	C4	15 ±2a	39 ±12a	54 ±72a	15 ±1a	18 ±2a	28.2 ±23b
	Av.	35.75 ±26a	114.25 ±95a	73.00 ±54a	61.00 ±61a	55.33 ±55a	
Table 5.3.3. Straw yield	CT	410 ±5a	1028±105a	560 ±63a	985 ±200a	475 ±67a	691.6 ±315a
	RT	584 ±40b	871 ±168a	954 ±58a	1000 ±22a	920 ±144a	865.8 ±215a

(kg/dunum)	**C8**	59 ±21a	244 ±65a	207 ±42a	136 ±21a	176 ±96a	164.4 ±106b
	C4	169 ±31a	370 ±83b	397 ±98a	145 ±10b	269 ±48ab	270 ±140b
	Av.	305.50 ±218a	628.25 ±382a	529.50 ±304a	566.50 ±469a	460.00 ±331a	

- Comparison of means using one-way ANOVA and LSD.
†: Comparison of means using Independent samples kruskal wallis test.
- 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^3/dunum ($M_{6m}{}^3$), Manure 3m^3/dunum + 6.25kg/dunum TSP + 6.25 kg/dunum AS ($M_{3m}{}^3/TSP_{6.25kg}/AS_{6.25kg}$), Manure 3m^3/dunum +12.5 kg/dunum TSP ($M_{3m}{}^3/TSP_{12.5kg}$), Manure 3m^3/dunum +12.5 kg/dunum AS ($M_{3m}{}^3/AS_{12.5kg}$).

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×$M_{6m}{}^3$ (4.10) followed by RT× $M_{3m}{}^3/TSP_{12.5kg}$ (Table 5.4.1). Similar trends go also with RT and stem length trait, however its highest values were recorded for RT× $M_{3m}{}^3/TSP_{12.5kg}$ and CT× $M_{6m}{}^3$ (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 $M_{3m}{}^3/TSP_{6.25kg}/AS_{6.25kg}$ mixed fertilizer which showed slightly lower than CT. Here, the highest spike length was registered for RT×$M_{3m}{}^3/AS_{12.5kg}$ (14.99 cm) followed by RT× $M_{6m}{}^3$ (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 $M_{3m}{}^3/TSP_{12.5kg}$ presented significantly the highest value followed significantly by $M_{6m}{}^3$ (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× $M_{3m}{}^3/AS_{12.5kg}$ and RT× $M_{3m}{}^3/TSP_{6.25kg}/AS_{6.25kg}$ by 39.13 and 39.10 respectively.

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

Variables	Tillage systems	(Fertilization treatments)					Av.
		Control	$M_{6m}{}^{3}$	$M_{3m}{}^{3}/TSP_{6.25kg}/AS_{6.25kg}$	$M_{3m}{}^{3}/TSP_{12.5kg}$	$M_{3m}{}^{3}/AS_{12.5kg}$	
Table 5.4.1. Tillers (cm)	CT	2.00±0.29a	3.50±0.42a	1.60±0.15a	3.60±0.30a	2.20±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 ±10cd
	C4	54 ±1.72b	70 ±3.62ab	72 ±4.14ab	85 ±6.70a	64 ±2.50ab	69 ±12c
	Av.	59.75 ±11b	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±0.65a	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±2.2b	34.57±2.02ab	28.93±2.56a	30.23±4.01a	30.33±3.31a	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	32.336a	

- Comparison of means using one-way ANOVA and LSD.
†: Comparison of means using Independent samples kruskal wallis test.
- 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 $6m^3$/dunum ($M_{6m}{}^{3}$), Manure $3m^3$/dunum + 6.25kg/dunum TSP + 6.25 kg/dunum AS ($M_{3m}{}^{3}/TSP_{6.25kg}/AS_{6.25kg}$), Manure $3m^3$/dunum +12.5 kg/dunum TSP ($M_{3m}{}^{3}/TSP_{12.5kg}$), Manure $3m^3$/dunum +12.5 kg/dunum AS ($M_{3m}{}^{3}/AS_{12.5kg}$).

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 M_{6m}^{3} 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× $M_{6m}{}^3$ 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 $M_{3m}{}^3/TSP_{12.5kg}$ (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 $M_{3m}{}^3/TSP_{6.25kg}/AS_{6.25kg}$ comparing to the $M_{3m}{}^3/TSP_{12.5kg}$ 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× $M_{3m}{}^3/AS_{12.5kg}$ and CT× $M_{3m}{}^3/AS_{12.5kg}$ 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/m^2) while conventional tillage presented the lowest value (405 tiller/m^2). 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 ($M_{6m}{}^3$) 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 ($M_{6m}{}^{3}$) 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 $M_{3m}{}^{3}/TSP_{12.5kg}$ 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.

REFERENCES:

1. Abbas, G., Khattak, J., Mir, A., Ishaque, M., Hussain, M., Wahedi, H. M., Ahmed, M. S., & Ullah, A. (2012). Effect of organic manures with recommended dose of NPK on the performance of wheat (*Triticum aestivum* L.). J.Anim. Plant Sci., 22(3), 683-687.
2. Abdalla, M., Osborne, B., Lanigan, G., Forristal, D., Williams, M., Smith, P., & Jones, M. N. (2013). Conservation tillage systems: a review of its consequences for greenhouse gas emissions, Soil Use Manage., 29, 199–209.
3. Abedi, T., Alemzadeh, A., & Kazemeini, S. A. (2010). Effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat. Australian Journal of Crop Science, 4(6), 384-389.
4. Abhinandan, K., Skori, L., Stanic, M., Hickerson, N. M., Jamshed, M., & Samuel, M. A. (2018). Abiotic stress signaling in wheat – an inclusive overview of hormonal interactions during abiotic stress responses in wheat. Front. Plant Sci., 9: Article 734. http://doi.org/10.3389/fpls.2018.00734
5. Abu Hammad, A., & Salameh, A. (2018). Temperature analysis as an indicator of climate change in the Central Palestinian Mountains. Theoretical and Applied Climatology. 136, 1453- 1464. http://doi.org/10.1007/s00704-018-2561-y
6. Acar, M., Çelik, I., & Günal, H. (2017). Effects of long-term tillage systems on soil water content and wheat yield under Mediterranean conditions. Journal of New Theory, 17, 98-108.
7. Ajlouni, M., Kruse, A., Condori-Apfata, J. A., Valencia, M. V., Hoagland, C., Yang, Y., & Mohammadi, M. (2020). Growth Analysis of Wheat Using Machine Vision: Opportunities and Challenges. Sensors. 20(22), Article 6501. https://doi.org/10.3390/s20226501
8. Alam, M. K, Islam, M. M, Salahin, N., & Hasanuzzaman, M. (2014). Effect of tillage practices on soil properties and crop productivity in wheat-Mungbean-Rice cropping system under subtropical climatic conditions. The science world journal, 2014, Article 437283. https://doi.org/10.1155/2014/437283
9. Albaba, I. (2017). Assessment of Climate change impacts on wheat and Barley production quality and quantity in Palestine. International Journal of Botany Studies, 2, 52-54.

10. Ali, N., Khan, M. N., Ashraf, M. S., Ijaz, S., Saeed-ur-Rehman, H., Abdullah, M., Ahmad, N., Akram, H. M,. & Farooq, M. (2020). Influence of different organic manures and their combinations on productivity and quality of bread wheat. J Soil Sci Plant Nutr., 20, 1949–1960. https://doi.org/10.1007/s42729-020-00266-2
11. Ali, S., Ibin-i Zami, M. S., Farid, M., Farooq, M. A., Rizwan, M., Ahmad, R., & Hannan, F. (2016). Growth and yield response of wheat (*Triticum aestivum* L.) to tillage and row spacing in maize-wheat cropping system in semi-arid region.Eurasian J Soil Sci., 5, 53 - 61. http://doi.org/10.18393/ejss.2016.1.053-061
12. Al-Salimiyia, M., De Luigi, G., Abu-Rabada, E., Ayad, H., & Basheer-Salimia, R. (2018).Adaption of Wheat Genotypes to Drought Stress. International Journal of Environment, Agriculture and Biotechnology (IJEAB), 3(1), 182-186. http://dx.doi.org/10.22161/ijeab/3.1.23
13. Al-Sari, M. I., Sarhan, M. A. A., & Al-Khatib, I. A. (2018). Assessment of compost quality and usage for agricultural use: a case study of Hebron, Palestine. Environ Monit Assess., 190(4), Article 223. https://doi.org/10.1007/s10661-018-6610-x
14. Amini, S., & Asoodar, M. A. (2014). The Effect Of Conservation Tillage On Environment, Weather And Water Pollution (The Review). International Journal of Agriculture and Crop Sciences. 7(6), 315-321.
15. Araus, J. L, Ferrio, J. P., Voltas, J., Aguilera, M., & Buxó, R. (2014). Agronomic conditions and crop evolution in ancient Near East agriculture. Nat. Commun. 5, Article 3953. https://doi.org/10.1038/ncomms4953
16. Araya, A., Kisekka, I., Girma, A., Hadgu, K. M., Tegebu, F. N., Kassa, A. H., Ferreira-Filho, H. R., Beltrão, N. E., Afewerk, A., Abadi, B., Tsehaye, Y., Martorano, L. G., & Abraha, A. Z. (2016). The challenges and opportunities for wheat production under future climate in Northern Ethiopia. Journal of Agricultural Science, 155(3), 379–393. https://doi.org/10.1017/S0021859616000460
17. Arshad, I., Ali, W. & Khan, Z. A. (2014). Effect of Different Levels of NPK Fertilizers on the Growth and Yield of Greenhouse Cucumber (Cucumis Sativus) By Using Drip Irrigation Technology. International Journal of Research (IJR), 1(8), 650-660.

https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.670.9446&rep=rep1&type=pdf

18. Ashfaq, M., Khan, A., & Ali, Z. (2003). Association of Morphological Traits with Grain Yield in Wheat (*Triticum aestivum* L.). International journal of agriculture & biology, 5(3), 262–264. http://doi.org/1560–8530/2003/05–3–262–264
19. Askari, M., & Khalifahamzehghasem, S. (2013). Draft force inputs for primary and secondary tillage implements in a clay loam soil. World applied sciences journal, 21(12), 1789-1794.
20. Asseng, S., Milory, S., Bassu, S., & Abi Saab, M. (2012). Wheat. In: P. Steduto, T. C. Hsiao, E. Fereres, & D. Raes (Eds.), Crop Yield Response to water. (pp. 92-101). FAO Irrigation and Drainage Paper Nr. 66. Rome, Italy.
21. Baker, C. J., Saxton, K. E., & Ritchie W.R. (2002). No-Tillage Seeding: Science and Practice (2nd ed.) Oxford, UK: CAB International.
22. Balfourier, F., Bouchet, S., Robert, S., De Oliveira, R., Rimbert, H., Kitt, J., Choulet, F., & Paux, E. 2019. Worldwide phylogeography and history of wheat genetic diversity. Science Advances, 5(5), Article eaav0536. http://doi.org/10.1126/sciadv.aav0536
23. Bálint, A. F., Kovács, G., & Sutka, J. (2000). Origin and taxonomy of wheat in the light of recent research. Acta agronomica Hungarica, 48(3), 301–313.
24. Banerjee, V., Krishnan, P.,∗Das, B., Verma, A. P. S., and Varghese, E. (2015). Crop Status Index as an indicator of wheat crop growth condition under abiotic stress situations. Field crops research, 181, 16–31.
25. Basheer-Salimia, R., & Atawnah, S. (2014). Morphological features, yield components and genetic relatedness of some wheat genotypes grown in Palestine. World journal of agricultural research, 2, 12-21.
26. Basheer-Salimia, R., & Ward, J. K. (2014). Climate change and its effects on olive tree physiology in Palestine. review of research, 3(5), http://oldror.lbp.world/UploadedData/688.pdf
27. Bedeke, S., Vanhove, W., Gezahegn, M., Natarajan, K., & Damme, P. V. (2019). Adoption of climate change adaptation strategies by maize-dependent smallholders in Ethiopia. NJAS - Wageningen Journal of Life Sciences, 88, 96–104.

28. Beral, A., Rincent, R., Le Gouis, J., Girousse, C., & Allard, V. (2020). Wheat individual grain-size variance originates from crop development and from specific genetic determinism. PLoS ONE, 15(3), Article e0230689. http://doi.org/10.1371/journal.pone.0230689
29. Biberdzic, M., Barac, S., Lalevic, D., Djikic, A., Prodanovic, D., & Rajicic, V. (2019). Influence of soil tillage system on soil compaction and winter wheat yield. Chilean journal of agricultural research, 80, 80-89. http://dx.doi.org/10.4067/S0718-58392020000100080
30. Bogunovic, I., Pereira, P., Kisic, I., Sajko, K., & Sraka, M. (2018). Tillage management impacts on soil compaction, erosion and crop yield in Stagnosols (Croatia). Catena, 160, 376–384.
31. Boussakouran, A., Sakar, E., El Yamani, M., & Rharrabti, Y. (2019). Morphological Traits Associated with Drought Stress Tolerance in Six Moroccan Durum Wheat Varieties Released Between 1984 and 2007. J. Crop Sci. Biotech., 22, 345-353. http://doi.org/10.1007/s12892-019-0138-0
32. Brouder, S. M., & Gomez-Macpherson, H. (2014). The impact of conservation agriculture on smallholder agricultural yields: A scoping review of the evidence. Agriculture, Ecosystems and Environment, 187, 11–32. https://doi.org/10.1016/j.agee.2013.08.010
33. Brunel, N.,Seguel, O., & Acevedo E. (2013). Conservation tillage and water availability for wheat in the dry land of central Chile. Journal of Soil Science and Plant Nutrition, 13(3), 622-637. http://dx.doi.org/10.4067/S0718-95162013005000050
34. Brupbacher, R. H.(1968). Analytical methods and procedures used in the soil testing laboratory . LSU Agricultural Experiment Station Reports. 454. http://digitalcommons.lsu.edu/agexp/454
35. Büchi, L.,Wendling, M., Amossé, C., Necpalova, M., & Charles, R. (2018). Importance of cover crops in alleviating negative effects of reduced soil tillage and promoting soil fertility in a winter wheat cropping system. Agriculture, Ecosystems and Environment, 256, 92–104. https://doi.org/10.1016/j.agee.2018.01.005
36. Celik, I., Barut, Z. B., Ortas, I., Gok, M., Demirbas, A., Tulun, Y., & Akpinar, C. (2011). Impacts of different tillage practices on some soil

microbiological properties and crop yield under semi-arid Mediterranean conditions. International Journal of Plant Production, Vol. 5(3), 237-254.

37. Chaghazardi, H. R,. Jahansouz, M. R., Ahmadi, A., & Gorji, M. (2016). Effects of tillage management on productivity of wheat and chickpea under cold, rainfed conditions in western Iran. Soil & Tillage Research, 162, 26–33. https://doi.org/10.1016/j.still.2016.04.010
38. Chen, W., Zhang, J., & Deng, X. (2019). The spike weight contribution of the photosynthetic area above the upper internode in a winter wheat under different nitrogen and mulching regimes. THE CROP JOURNAL, 7, 89–100.
39. Cossani, C. M., and Reynolds, M. P. (2012). Physiological Traits for Improving Heat Tolerance in Wheat. Plant Physiology, 160, 1710–1718.
40. Csorba, G., Krivek, G., Sendula, T., Homonnay, Z. G., Hegyeli, Z., Sugar, S., Farkas, J., Stojnić, N., & Németh, A. (2015).How can scientific researches change conservation priorities? A review of decade-long research on blind mole-rats (Rodentia: Spalacinae) in the Carpathian Basin. THERYA, 6 :103-121. http://doi.org/10.12933/therya-15-245
41. Dai, X., Xiao, L., Jia, D., Kong, H., Wang, Y., & Li, C. (2014). Increased plant density of winter wheat can enhance nitrogen–uptake from deep soil. Plant and Soil, 384, 141–152. https://doi.org/10.1007/s11104-014-2190-x
42. Darai, R., Ojha, B., Sarker, A., & Sah, R. (2016). Genetics and breeding for drought tolerance in food legumes. International Journal of Environment, Agriculture and Biotechnology (IJEAB). Vol. 1, 958-967. http://doi.org/10.22161/ijeab/1.4.47
43. Devi, K. G., .Sowmiya, N., Yasoda, K., Muthulakshmi, K., & Kishore, B. (2020). Review on application of drones for crop health monitoring and spraying pesticides and fertilizer. Journal of critical reviews, 7(6), 667- 672. http://doi.org/10.31838/jcr.07.06.117
44. Dimkpa, C. O., Andrews, J., Sanabria, J., Bindraban, P. S., Singh, U., Elmer, W. H., GardeaTorresdey, J. L. & White, J. C. (2020). Interactive effects of drought, organic fertilizer, and zinc oxide nanoscale and bulk particles on wheat performance and grain nutrient accumulation. Sci. Total Environ., 722, Article 137808. http://doi.org/10.1016/j.scitotenv.2020.137808
45. Djuric, N., Prodanovic, S., Brankovic, G., Djekic, V., Cvijanovic, G., Zilic, S., Dragicevic, V., Zecevic, V., & Dozet, G. (2018). Correlation-Regression

Analysis of Morphological-Production Traits of Wheat Varieties. Romanian Biotechnological Letters, 23(2), 13457-13465.

46. Doroshkov, A. V., Pshenichnikova, T. A., & Afonnikov, D. A. (2011). Morphological Characterization and Inheritance of Leaf Hairiness in Wheat (*Triticum aestivum* L.) as Analyzed by Computer Aided Phenotyping. Russian Journal of Genetics, 47(6), 739–743.
47. Drobek, M., Frac., M., & Cybulska, J. (2019). Plant Biostimulants: Importance of the Quality and Yield of Horticultural Crops and the Improvement of Plant Tolerance to Abiotic Stress—A Review. Agronomy, Vol. 9(6), Article 335. https://doi.org/10.3390/agronomy9060335
48. Duchemin, B., Hadria, R., Erraki, S., Boulet, G., Maisongrande, P., Chehbouni, A., Escadafal, R., Ezzahar, J., Hoedjes, J., Kharrou, M., Khabba, S., Mougenot, B., Olioso, A., Rodriguez, J., & Simonneaux, V. (2006). Monitoring wheat phenology and irrigation in Central Morocco: On the use of relationships between evapotranspiration, crops coefficients, leaf area index and remotely-sensed vegetation indices. Agric. Water Manage, 79(1), 1–27. https://doi.org/10.1016/j.agwat.2005.02.013
49. Dursun, A., Turan, M., Ekinci, M., Gunes, A., Ataoglu, N., Esringü, A., & Yildirim, E. (2010). Effects of Boron Fertilizer on Tomato, Pepper, and Cucumber Yields and Chemical Composition, Communications in Soil Science and Plant Analysis, 41(13), 1576-1593. http://doi.org/10.1080/00103624.2010.485238
50. Dvořák, J. (2001). Triticum Species (Wheat). In: S. Brenner, & J. H. Miller (Eds.), Encyclopedia of Genetics, (pp. 2060–2068). Academic Press, New York.
51. Efretuei, A., Gooding, M., White, E., Spink, J., & Hackett, R. (2016). Effect of nitrogen fertilizer application timing on nitrogen use efficiency and grain yield of winter wheat in Ireland Irish. Journal of Agricultural and Food Research. 55, 63-73. http://doi.org/10.1515/ijafr-2016-0006
52. Elazari-Volcani, I. (1925). Transition from Primitive to Modern Agriculture, Palestine Economic Society, Rehovoth, Tel Aviv.
53. Elizabath, A., Babychan, M., Mathew, A. M., & Syriac, G. M. (2019). Application of Nanotechnology in Agriculture. Int. J. Pure App. Biosci., 7(2), 131-139. http://dx.doi.org/10.18782/2320-7051.6493

54. Eludoyin, A., Eludoyin, O., & Eslamian, S. (2017). Drought Mitigation Practices. In S. Eslamian, & F. Eslamian (Eds.). Handbook of Drought and Water Scarcity (pp. 391-400), Francis and Taylor, CRC Press, USA.
55. Elzinga, C. L., Salzer, D. W., & Willoughby, J. W. (1998). Measuring and Monitoring Plant Populations (pp. 113–135). Bureau of Land Management, Denver, CO. BLM Technical Reference.
56. FAO. (2020). Publication of the Food and Agricultural Organization of the United Nations, World Food Program,Crop Prospects and Food Situation #1, Quarterly Global Report. Rome, Italy. http://www.fao.org/3/ca8032en/ca8032en.pdf
57. FAOSTAT. (2018). the Statistics Division of the Food and Agriculture Organization of the United Nations, http://www.faostat.fao.org.
58. FAOSTAT. (2020). the Statistics Division of the Food and Agriculture Organization of the United Nations, http://www.faostat.fao.org.
59. Farooq, M. U., Cheema, A. A., Ishaaq, I., & Zhu, J. (2018). Correlation and genetic component studies for peduncle length affecting grain yield in wheat. International Journal of Advanced and Applied Sciences, 5(10), 67-75.
60. Fazily, T., & Hunshal, C. S. (2019). Effect of organic manures on yield and economics of late sown wheat (*Triticum aestivum*). International journal of research & review, 6(1), 168-171. https://www.ijrrjournal.com/IJRR_Vol.6_Issue.1_Jan2019/IJRR0025.pdf
61. Feller, C., Blanchart, E., Bernoux, M., Lal, R., & Manlay, R. (2012). Soil fertility concepts over the past two centuries: the importance attributed to soil organic matter in developed and developing countries. Arch. Agron. Soil Sci., 58, S3–S21. https://doi.org/10.1080/03650340.2012.693598
62. Fioreze, S., Castoldi, G., Pivetta, L. A., Pivetta, L. G., Fernandes, D., & Büll, L. (2012). Tillering of two wheat genotypes as affected by phosphorus levels. Acta Sci. Agron., 34(1), 331-338. https://doi.org/10.1590/S1807-86212012000300014
63. Fowler, D. B. (2018). Growth stages of wheat. In: Winter wheat production manual. Ducks Unlimited Canada and Conservation Production Systems Ltd.
64. Fuentes, J. P., Flury, M., Huggins, D. R., & Bezdicek, D. F. (2003). Soil water and nitrogen dynamics in dryland cropping systems of Washington State, USA. Soil & Tillage Research, 71, 33–47.

65. Gangwar, H. K., Singh, G., Srivastava, M., Jaiswal, P., Pal, S., Kumar, D., & Singh, A. (2019). Effect of tillage management modules and seed rates on yield and economic of late sown varieties of wheat (*Triticum aestivum L.*) in rice fallow. Journal of Pharmacognosy and Phytochemistry, 8(6), 466-469.
66. Gesch, R., Dose, H., & Forcella, F. (2016). Camelina growth and yield response to sowing depth and rate in the northern corn belt USA. Industrial crops and products. 95, 416-421. http://dx.doi.org/10.1016/j.indcrop.2016.10.051
67. Ghaffar, S. H., Fan, M., Zhou, Y., & Abo Madyan, O. (2017). Detailed Analysis of Wheat Straw Node and Internode for their Prospective Efficient Utilisation. Journal of agricultural and food chemistry, http://doi.org/10.1021/acs.jafc.7b03304
68. Ghaley, B. B., Wösten, H., Olesen, J. E., Schelde, K., Baby, S., Karki, Y. K., Børgesen, C. D., Smith, P., Yeluripati, J., Ferrise, R., Bindi, M., Kuikman, P., Lesschen, J. P., Porter, J. R. (2018). Simulation of soil organic carbon effects on long-term winter wheat (*Triticum aestivum*) production under varying fertilizer inputs. Frontiers in Plant Science, 9. https://doi.org/10.3389/fpls.2018.01158
69. Gholami, A., Asgari, H. R., & Zeinali, E. (2014). Effect of different tillage systems on soil physical properties and yield of wheat (Case study: Agricultural lands of Hakim Abad village, Chenaran township, Khorasan Razavi province). International journal of advanced biological and biomedical research, 2(5), 1539-1552.
70. Goncharov, N. P. (2011). Genus *Triticum L.* taxonomy: the present and the future. Plant Syst Evol., 295, 1–11. https://doi.org/10.1007/s00606-011-0480-9
71. Goncharov, N. P., Golovnina, K. A., & Kondratenko, E. Y. (2009). Taxonomy and molecular phylogeny of natural and artificial wheat species. Breeding Science, 59, 492–498.
72. Gooding, M. J. (2009). The wheat crop. In: K. Khan, & P. R. Shewry (Eds.). Wheat: Chemistry and Technology (4th ed., pp. 35–70). Minnesota, USA: AACC International.
73. Haile, D., Nigussie, D., & Ayana, A. (2012). Nitrogen use efficiency of bread wheat: Effects of nitrogen rate and time of application. Journal of soil science

and plant nutrition, 12(3), 389-409. http://dx.doi.org/10.4067/S0718-95162012005000002

74. Halpern, M., Bar-Tal, A., Ofek, M., Minz, D., Muller, T., & Yermiyahu, U. 2015. The use of biostimulants for enhancing nutrient uptake. In: D. L. Sparks, (Eds.), Advances in Agronomy (pp. 141-174). Elsevier. https://doi.org/10.1016/bs.agron.2014.10.001
75. Hammad, H. M., Khaliq, A., Abbas, F., Farhad, W., Fahad, S., Aslam, M., Shah, G. M., Nasim, W., Mubeen, M., & Bakhatk Hl F. (2020). Comparative effects of organic and inorganic fertilizers on soil organic carbon and wheat productivity under arid region. Communications in soil science and plant analysis, 51(10), https://doi.org/10.1080/00103624.2020.1763385
76. Hasanuzzaman, M., Bhuyan, M. H., Nahar, K., Hossain, M. S., Al Mahmud, J., Hossen, M. S., Masud, A. A., Moumita, & Fujita, M. (2018). Potassium: A vital regulator of plant responses and tolerance to abiotic stresses. Agronomy, 8(3), Article 31. https://doi.org/10.3390/agronomy8030031
77. Hatfield, J. L,. & C. Dold. (2018). Agroclimatology and Wheat Production: Coping with Climate Change. Frontiers in Physiology, 9, Article 224. http://doi.org/10.3389/fpls.2018.00224
78. Hazra, G. (2016). Different types of eco-friendly fertilizers: an overview. Sustainability in Environment, 1(1), 54- 70. https://doi.org/10.22158/se.v1n1p54
79. Hofmeijer, M., Krauss, M., Berner, A., Peigné, J., Mäder, J., & Armengot, L. (2019). Effects of reduced tillage on weed pressure, nitrogen availability and winter wheat yields under organic management. Agronomy, 9(4), Article 180. https://doi.org/10.3390/agronomy9040180
80. Holland, J. M. (2004). The environmental consequences of adopting conservation tillage in Europe: reviewing the evidence. Agriculture, Ecosystems and Environment, 103(1), 1–25. https://doi.org/10.1016/j.agee.2003.12.018
81. Houben, D., Faucon, M., & Mercadal, A. (2018). Response of organic matter decomposition to no-tillage adoption evaluated by the tea bag technique. Soil Syst., 2(3), Article 42. https://doi.org/10.3390/soilsystems2030042
82. Huang, C., Yermiyahu, U., Shenker, M., & Ben-Gal, A. (2020). Effect of leaching events on the fate of polyhalite nutrient minerals used for crop

fertilization. Journal of Plant Nutrition, 43(16), 2518-2532. https://doi.org/10.1080/01904167.2020.1783294

83. Igrejas, G., & Branlard, G. (2020). The importance of wheat. In: G. Igrejas, T. M. Ikeda, & C. Guzmán, (Eds.). Wheat quality for improving processing and human health. Springer.
84. Imadi, S. R., Gul, A., Dikilitas, M., Karakas, S., Sharma, I., & Ahmad, P. (2016). Water stress: types, causes, and impact on plant growth and development. In: P. Ahmad (Eds), Water Stress and Crop Plants: A Sustainable Approach (pp. 343-355). John Wiley & Sons, Ltd; . http://doi.org/10.1002/9781119054450
85. Imran, A., Shafi, J., Akbar, N., Ahmad, W., Ali, M., & Tariq, S. (2013). Response of wheat (*Triticum aestivum*) cultivars to different tillage practices grown under rice-wheat cropping system. Uni. J. Plant. Sci., 1(4), 125-131. DOI: 10.13189/ujps.2013.010403
86. Iqbal, S., Riaz, U., Murtaza, G., Jamil, M., Ahmed, M., Hussain, A., & Abbas, Z. (2021). Chemical Fertilizers, Formulation, and Their Influence on Soil Health. In: K.R. Hakeem, G. H. Dar, M. A. Mehmood, & R. A. Bhat (Eds.). Microbiota and Biofertilizers (pp.1-15). Springer, Cham. https://doi.org/10.1007/978-3-030-48771-3_1
87. Jabloun, M., Schelde, K., Tao, F., & Olesen, J. E. (2015). Effect of temperature and precipitation on nitrate leaching from organic cereal cropping systems in Denmark. Europ. J. Agronomy, 62, 55–64. https://doi.org/10.1016/j.eja.2014.09.007
88. Jackson, S. T. (2021). Climate change. Encyclopedia Britannica. https://www.britannica.com/science/climate-change
89. Jiang, T., Liu, J., Gao, Y., Sun, Z., Chen, S., Yao, N., Ma, H., Feng, H., Yu, Q., & He, J. (2020). Simulation of plant height of winter wheat under soil Water stress using modified growth functions. Agricultural Water Management, 232, Article 106066. http://doi.org/10.1016/j.agwat.2020.106066
90. Jonard, F., Mahmoudzadeh, M., Roisin, C., Weihermüller, L., André, F., Minet, J., Vereecken, H., & Lambot, S. (2013). Characterization of tillage effects on the spatial variation of soil properties using ground-penetrating radar and electromagnetic induction. Geoderma, 207, 310–322.

91. Kanstrup, M., Holst, M. K., Jensen, P. M., Thomsen, I. K., & Christensen, B. T. (2013). Searching for long-term trends in prehistoric manuring practice. δ15N analyses of charred cereal grains from the 4th to the 1st millennium BC. Journal of Archaeological Science, 51, 115-125. http://doi.org/10.1016/j.jas.2013.04.018

92. Kayan, N., Kutlu, I., & Ayter, N. (2018). The influence of different tillage, crop rotations and nitrogen levels on plant height, biological and grain yield in wheat. AgroLife Scientific Journal, 7, 82-91.

93. Kesho, A., Chala, A., & Shikur, E. (2020).Fungi associated with wheat (*Triticum spp*.) in south east Ethiopia under storage conditions. Academic Research Journal of Agricultural Science and Research, 8(2), 109-117. DOI:10.14662/ARJASR2020.005

94. Khaliq, I., Irshad, A., & Ahsan, M. (2008). Awns and flag leaf contribution towards grain yield in spring wheat (*Triticum aestivum L.).* Cereal Research Communications, 36(1), 65–76. https://doi.org/10.1556/CRC.36.2008.1.7

95. Khorami, S. S., Kazemeini, S. A., Afzalinia, S., & Gathala, M. K. (2018). Changes in Soil Properties and Productivity under Different Tillage Practices and Wheat Genotypes: A Short-Term Study in Iran. Sustainability, 10, Article 3273. http://doi.org/10.3390/su10093273

96. Khursheed, M., & Mahammad, M. (2015). Effect of Different Nitrogen Fertilizers on Growth and Yield of Wheat. Zanco Journal of Pure and Applied Sciences, 27(5), 19-28. http://zancojournals.su.edu.krd/index.php/JPAS/article/view/226

97. Kinoshita, T., Yano, T., Sugiura, M., & Nagasaki, Y. (2014). Effects of Controlled-Release Fertilizer on Leaf Area Index and Fruit Yield in High-Density Soilless Tomato Culture Using Low Node-Order Pinching. PLoS ONE, 9(11), Article e113074. http://doi.org/10.1371/journal.pone.0113074

98. Krauss, M., Berner, A., Perrochet, F., Frei, R., Niggli, U., & Mäder, P. (2020). Enhanced soil quality with reduced tillage and solid manures in organic farming—A synthesis of 15 years. Sci. Rep.10, Article 4403. https://doi.org/10.1038/s41598-020-61320-8

99. Kumar, A., and Singh. A. (2014). Climate change and its impact on wheat production and mitigation through agroforestry technologies. International journal on environmental sciences, 5(1), 73-90.

100. Kumar, S., Meena, R. S., Jakhar, S. R., Jangir, C. K., Gupta, A., & Meena, B. L. (2019). Adaptation strategies for enhancing agricultural and environmental sustainability under current climate. In: R. S. Meena (Eds.), Sustainable agriculture (pp. 226–274). Scientific Publisher.
101. Kumar, V., Gathala, M. K., Saharawat, Y. S., Parihar, C. M., Kumar, R., Kumar, R., Jat, M. L., Jat, A. S., Mahala, D. M., Kumar, L., Nayak, H. S., Parihar, M. D., Rai, V., Jewlia, A., & Kuri, B. R. (2018). Impact of tillage and crop establishment methods on crop yields, profitability and soil physical properties in rice–wheat system of Indo-Gangetic Plains of India. Soil Use Manage, 35, 303–313.
102. Lal, R., Reicosky, D. L., & Hanson, J. D. (2007). Evolution of the plow over 10,000 years and the rationale for no-till farming. Soil and Tillage Research, 93(1), 1–12. https://doi.org/10.1016/j.still.2006.11.004
103. Lampurlanés, J., & Cantero-Martínez, C. (2003). Soil Bulk Density and Penetration Resistance under Different Tillage and Crop Management Systems and Their Relationship with Barley Root Growth. Agron. J., 95(3), 526–536. https://doi.org/10.2134/agronj2003.5260
104. Land research center. (2020). [Unpublished raw data on Zatara profile]. GIS and remote sensing department. (2019).
105. Leghari, N., Mirjat, M. S., Mughal, A., Rajpar, I., & Magsi, H. (2015). Effect of different tillage methods on the growth, development, yield and yield components of bread wheat. International Journal of Agronomy and Agricultural Research (IJAAR), 6(5), 36-46.
106. Lipiec, J., Doussan, C., Nosalewicz, A., & Kondracka, A. (2013). Effect of drought and heat stresses on plant growth and yield: a review. Int. Agrophys., 27(4), 463-477. https://doi.org/10.2478/intag-2013-0017
107. Liu, E., Changrong, Y., Xurong, M., Wenqing, H., So, H., Linping, D., Qin, L., Shuang, L., & Tinglu, F. (2010). Long term effect of chemical fertilizer, straw, and manure on soil chemical and biological properties in north-west China. Geoderma, Vol.150, pp:173–180.
108. Liu, Z., Gao, F., Liu, Y., Yang, J., Zhen, X., Li, X., Li, Y., Zhao, J., Li, J., Qian, B., Yang, D., & Li, X. (2019). Timing and splitting of nitrogen fertilizer supply to increase crop yield and e ciency of nitrogen utilization in a wheat–peanut

relay intercropping system in China. The Crop Journal, 7(1), 101–112. https://doi.org/10.1016/j.cj.2018.08.006

109. Lopez-Garrido, R., Madejon, E., León-Camacho, M., Girón, I., Moreno, F., & Murillo, J. (2014). Reduced tillage as an alternative to no-tillage under Mediterranean conditions: A case study, Soil & Tillage Research, 140, 40–47. https://doi.org/10.1016/j.still.2014.02.008

110. Lövy, M., Šklíba, J., Hrouzková, E., Dvořáková, V., Nevo, E., & Šumbera, R. (2015). Habitat and Burrow System Characteristics of the Blind Mole Rat Spalax galili in an Area of Supposed Sympatric Speciation. PLoS ONE, 10(7), Article e0133157. https://doi.org/10.1371/journal.pone.0133157

111. Lupwayi, N., Clayton, G., O'Donovan, J., Harker, K., Turkington, T., & Rice, W. (2004). Decomposition of crop residues under conventional and zero tillage. Canadian Journal of Soil Science, 84(4), 403–410. https://doi.org/10.4141/S03-082

112. Ma, B., Yu, X., Ma, F., Li, Z. & Wu, F. (2014). Effects of crop canopies on rain splash detachment. Plos One, Vol.9, pp:1-10.

113. Maina, J., Wandiga, S., Gyampoh, B., & Charles, G. K. (2020). Analysis of average annual rainfall and average maximum annual temperature for a period of 30 years to establish trends in kieni, central kenya. Climatol weather forecasting, 7, Article 249. DOI:10.35248/2332-2594.7.249

114. Małecka, I., Blecharczyk, A., Sawinska, Z., Swedrzynska, D., & Piechota, T. (2015). Winter wheat yield and soil properties response to long term non-inversion tillage. J. Agr. Sci. Tech., 17(6), 1571-1584.

115. Malghani, A., Malik, A., Sattar, A., Hussain, F., Abbas, G., & Hussain, J. (2010). response of growth and yield of wheat to npk fertilizer. Sci.Int.(Lahore), 24(2), 185-189.

116. Malhotra, S. K. (2016). Water soluble fertilizers in horticultural crops- An appraisal. Indian Journal of Agricultural Sciences, 86(10), 1245–1256.

117. Mar, S., Nomura, H., Takahashi, Y., Ogata, K., & Yabe, M. (2018). Impact of Erratic Rainfall from Climate Change on Pulse Production Efficiency in Lower Myanmar. Sustainability, 10(2), Article 402. https://doi.org/10.3390/su10020402

118. Maralian, H., Ebadi, A., Didar, T. R., & Haji-Eghrari, B. (2010). Influence of water deficit stress on wheat grain yield and proline accumulation rate. African

journal of agricultural research, 5(4), 286-289. https://academicjournals.org/article/article1380898477_Maralian%20et%20al.pdf

119. Martínez, A., Fuentes, J. P., Pino, V., Silva, P., & Acevedo, E. (2013). Chemical and biological properties as affected by no-tillage and conventional tillage systems in an irrigated Haploxeroll of Central Chile. Soil & Tillage Research, 126, 238–245. https://doi.org/10.1016/j.still.2012.07.014

120. Meharg, C., & Meharg, A. A. (2015). Silicon, the silver bullet for mitigating biotic and abiotic stress, and improving grain quality, in rice?. Environmental and Experimental Botany, 120, 8–17. https://doi.org/10.1016/j.envexpbot.2015.07.001

121. Mitchell, J. P., Klonsky, K., Shrestha, A., Fry, R., DuSault, A., Beyer, J., & Harben, R. (2007). Adoption of conservation tillage in California: current status and future perspectives. Australian Journal of Experimental Agriculture, 47(12), 1383–1388.

122. Mizyed, N. (2018). Climate Change Challenges to Groundwater Resources: Palestine as a Case Study. Journal of Water Resource and Protection, Vol.10, pp:215-229

123. Mohammadshirazi, F., McLaughlin, R. A,, Heitman, J. L,. & Brown, V. K. (2017). A multi-year study of tillage and amendment effects on compacted soils. Journal of Environmental Management, 203, 533-541.

124. Moitzi, G., Neugschwandtner, R. W., Kaul, H. P., & Wagentristl, H. (2021). Effect of tillage systems on energy input and energy efficiency for sugar beet and soybean under Pannonian climate conditions. Plant, Soil and Environment, 67(3), 137–146.

125. Mojid, M. A., Mustafa, S. M., & Wyseure, G. C. (2009). Growth, yield and water use efficiency of wheat in silt loam-amended loamy sand. J. Bangladesh Agril. Univ. 7(2), 403–410. https://www.banglajol.info/index.php/JBAU/article/view/4753

126. Monneveux, P., Jing, R., & Misra, S. C. (2012). Phenotyping for drought adaptation in wheat using physiological traits. Frontiers in Physiology, 3, Article 429. https://doi.org/10.3389/fphys.2012.00429

127. Moraru, P. I., & Rusu, T. (2012). Effect of tillage systems on soil moisture, soil temperature, soil respiration and production of wheat, maize and soybean crops. Journal of Food, Agriculture & Environment, 10(2), 445-448.
128. Morugán-Coronado, A., Linares, C., Gómez-López, M. D., Faz, A., & Zornoza, R. (2020). The impact of intercropping, tillage and fertilizer type on soil and crop yield in fruit orchards under Mediterranean conditions: A meta-analysis of field studies. Agricultural Systems, 178, Article 102736. http://doi.org/10.1016/j.agsy.2019.102736
129. Mukhtiar, A., Waqar, A., Khalil, M., Tariq, M., Muhammad, S., Hussain, A., & Kamal, A. (2018). Evaluating the potential organic manure for improving wheat yield and quality under agro-climatic conditions of Pakistan. Advances in Crop Science and Technology. 6, Article 349. http://doi.org/10.4172/2329-8863.1000349
130. Murillo, J. M., Moreno, F., Girón, I. F., & Oblitas, M. I. (2004). Conservation tillage: long term effect on soil and crops under rainfed conditions in south-west Spain (Western Andalusia).Spanish Journal of Agricultural Research, 2(1), 35-43. http://doi.org/10.5424/sjar/2004021-58
131. Murtaza, G., Rasool, F., Habib, R., Javed, R., Sardar, K., Ayub, M. M., Ayub, M. A., & Rasool, A. (2016). A Review of Morphological, Physiological and Biochemical Responses of Plants under Drought Stress Conditions. Imperial Journal of Interdisciplinary Research (IJIR), 2(12), 1600-1606.
132. Nagendran, R. (2011). Agricultural waste and pollution. In Waste: A handbook for management (pp. 341-355). Elsevier, India. http://doi.org/10.1016/B978-0-12-381475-3.10024-5
133. Nene, Y. L. (2018). The Concept and Formulation of Kunapajala, the World's Oldest Fermented Liquid OrganicManure. Asian Agri-History, 22(1), pp: 8-14. http://doi.org/10.17485/aah/2018/v22i1/18292
134. Neukam, D., Ahrends, H., Luig, A., Manderscheid, R., & Kage, H. (2016). Integrating wheat canopy temperatures in crop system models. Agronomy, Vol. 6(1), https://doi.org/10.3390/agronomy6010007
135. Nezhadahmadi, A., Prodhan, Z. H., & Faruq, G. (2014). Drought Tolerance in Wheat. The ScientificWorld Journal, 2013, Article 610721. http://doi.org/10.1155/2013/610721

136. Nosratabad, A., Etesami, H., & Shariati, S. (2017). Integrated use of organic fertilizer and bacterial inoculant improves phosphorus use efficiency in wheat (*Triticum aestivum* L.) fertilized with triple superphosphate. Rhizosphere, 3, 109–111. https://doi.org/10.1016/j.rhisph.2017.03.001
137. Nuttall, J. G., O'Leary, G. J., Panozzo, J. F., Walker, C. K., Barlow, K. M., & Fitzgeralda, G. J. (2017). Models of grain quality in wheat—A review. Field Crops Research, 202, 136–145.
138. Ofer, B. (1998). The Natufian Culture in the Levant, Threshold to the Origins of Agriculture. Evolutionary Anthropology, 6(5),159–177.
139. Olsen, J., Kristensen, L., & Weiner, J. (2005). Effects of density and spatial pattern of winter wheat on suppression of different weed species. Weed Science, 53(5), 690-694. https://doi.org/10.1614/WS-04-144R2.1
140. Öztürk, A., and Aydin, M. (2017). Physiological characterization of Turkish bread wheat genotypes for resistance to late drought stress. Turkish Journal of Agriculture and Forestry, 41(6), 414-440. http://doi.org/10.3906/tar-1705-54
141. Palestinian Astronomical Society. (2020). [Unpublished raw data on precipitation and temperature]. (2019).
142. Palestinian Ministry of Agriculture. (2018). [Unpublished raw data on the statistics of field crops]. Field crops department. (2017).
143. Palestinian Ministry of Agriculture. (2020). [Unpublished raw data on the statistics of field crops]. Field crops department.(2019)
144. Palmer, C. (2002). Milk and Cereals: Identifying Food and Food Identity among Fallāhīn and Bedouin in Jordan.The Journal of the Council for British Research in the Levant, 43, 173-195. https://doi.org/10.1179/lev.2002.34.1.173
145. Pan, F., Yu, W., Ma, Q., Zhou, H., Jiang, C., Xu, G., & Ren, J. (2017). Influence of 15N-labeled ammonium sulfate and straw on nitrogen retention and supply in different fertility soils. Biol. Fertil. Soils, 53, 303–313. http://doi.org/10.1007/s00374-017-1177-1
146. Panozzo, A., Huang, H., Bernazeau, B., Vamerali, T., Samson, M. F., & Desclaux, D. (2020). Morphology, Phenology, Yield, and Quality of Durum Wheat Cultivated within Organic Olive Orchards of the Mediterranean Area. Agronomy, 10, Article1789. http://doi.org/10.3390/agronomy10111789
147. Pansu, M., & Gautheyrou, J. (2006). Handbook of Soil Analysis Mineralogical, Organic and Inorganic Methods. Springer-Verlag, Heidelberg.

148. PCBS. (2018). Agricultural Statistics. Palestinian Central Bureau of Statistics,(2017).

149. Peigné, J., Vian, J., Payet, V., & Saby, N. P. (2018). Soil fertility after 10 years of conservation tillage in organic farming. Soil & Tillage Research. 175, 194-204. http://dx.doi.org/10.1016/j.still.2017.09.008

150. Peigné, J., Messmer, M., Aveline, A., Berner, A., Mäder, P., Carcea, M., Narducci, V., Samson, M. F., Thomsen, I. K., Celette, F,. & David, C. (2014). Wheat yield and quality as influenced by reduced tillage in organic farming. Org. Agr., 4(1), 1–13. https://link.springer.com/article/10.1007/s13165-013-0055-x

151. Petrarulo, M., Marone, D., Ferragonio, P., Cattivelli, L., Rubiales, D., De Vita, P., & Mastrangelo, A. M. (2014). Genetic analysis of root morphological traits in wheat. Mol Genet Genomics, 290, 785–806. http://doi.org/10.1007/s00438-014-0957-7

152. Pittelkow, C. M., Linquist, B. A., Lundy. M. E., Liang, X., Van Groenigen, K. J., Lee, J., Van Gestel, N., Six, J., Venterea, R. T., & Van Kessel, C. (2015). When does no-till yield more? A global meta-analysis.Field Crops Research, 183, 156–168. https://doi.org/10.1016/j.fcr.2015.07.020

153. Plume, A., Dinaburga, G., Kopmanis, J., Lapins, D., & Berzins, A. Effect of soil deep ploughing on winter wheat depending on soil conditions. Engineering for Rural Development. Proceedings of the Inernational Scientific Conference (Latvia). http://www.tf.llu.lv/conference/proceedings2009/Papers/04_Aigars_Plume.pdf

154. Prasad, R. (2009). Efficient fertilizer use: The key to food security and better environment. Journal of Tropical Agriculture, 47(1), pp. 1-17.

155. Pshenichnikova, T. A., Doroshkov, A. V., Simonov, A. V., Afonnikov, D. A., & Borner, A. (2016). Diversity of leaf pubescence in bread wheat and relative species. Genet Resour Crop Evol., 64,1761–1773, http://doi.org/10.1007/s10722-016-0471-3

156. Ramos, M. C., Pareja-Sánchez, E., Plaza-Bonilla, D., Cantero-Martínez, C., & Lampurlanés, J. (2019). Soil sealing and soil water content under no□tillage and conventional tillage in irrigated corn: Effects on grain yield. Hydrological Processes, 33(15), 2095–2109. https://doi.org/10.1002/hyp.13457

157. Rao, G., Chaudhary, H., & Singh, P. (2018). Optimal Draft requirement for vibratory tillage equipment using Genetic Algorithm Technique. IOP Conf. Ser.: Mater. Sci. Eng. 330, Article 012108. http://doi.org/10.1088/1757-899X/330/1/012108
158. Raper, R. L. (2005). force requirements and soil disruption of straight and bentleg subsoilers for conservation tillage systems. Applied engineering in agriculture, 21(5), 787−794.
159. Rasul, G., Ahmed, S., & Ahmed, M. (2015). Influence of different organic fertilizers on growth and yield of wheat. Am-Euras. J. Agric. & Environ. Sci., 15(6), 1123-1126. https://www.idosi.org/aejaes/jaes15(6)15/22.pdf
160. Raza, A., Razzaq, A., Mehmood, S. S., Zou, X., Zhang, X., Lv, Y., and Xu. J. (2019). Impact of Climate Change on Crops Adaptation and Strategies to Tackle Its Outcome: A Review. Plants, 8(2), Article 34. http://doi.org/10.3390/plants8020034
161. Reicosky, D. C. (2015). Conservation tillage is not conservation agriculture. Journal of soil and water conservation, 70(5), 103-108.
162. Roul, T. K., Panda, M. R., Mohanty, B., Sardar, K. K., Dehuri, M., Hembram, A., & Mohapatra, T. (2017). Effects of commonly used chemical fertilizers on development of free-living stages of *Haemonchus contortus* in experimentally infected pasture. Veterinary World, 10(7), 764-768.
163. Ruiz, M., Zambrana, E., Fite, R., Sole, A., Tenorio, J. L,. & Benavente, E. (2019). Yield and quality performance of traditional and improved bread and durum wheat varieties under two conservation tillage systems. Sustainability, 11(17), Article 4522. https://doi.org/10.3390/su11174522
164. Safi, A., & Mohammad, A. G. (2019). Impacts of different water harvesting techniques on barley productivity under semi-arid conditions in Palestine. Hebron University Research Journal(A), 8, 66-80.
165. Salama, A., Al-Omari, A., Abbady, N., & Jarrar, S. (2014). common wheat varieties in Palestine (descriptive manual). Ramallah, Palestine.
166. Salem, H. M., Valero, C., Muñoz, M. Á., Rodríguez, M. G., & Silva L. L. (2015). Short-term effects of four tillage practices on soil physical properties, soil water potential, and maize yield. Geoderma, Vol. 237, 60–70. https://doi.org/10.1016/j.geoderma.2014.08.014

167. Savci, S., (2012). Investigation of Effect of Chemical Fertilizers on Environment. APCBEE Procedia, 1, 287 – 292. https://doi.org/10.1016/j.apcbee.2012.03.047
168. Schneider, F., Don, A., Hennings, I., Schmittmann, O., & Seidel, S. J. (2017). The effect of deep tillage on crop yield – What do we really know?. Soil & Tillage Research, 174, 193–204.
169. Senay, G., Velpuri, N., Bohms, S., Budde, M., Young, C., Rowland, J., & Verdin, J. (2015). Drought monitoring and assessment: Remote sensing and modeling approaches for the Famine Early Warning Systems Network. In P. Paron, G. Di Baldassarre, J. F. Shroder, (Eds.), Hydro-meteorological hazards, risks and disasters (pp. 233–262).
170. Shahzad, M., Farooq, M., Jabran, M., Yasir, T. A., & Hussain, M. (2016). Influence of Various tillage practices on soil physical properties and wheat performance in different wheat-based cropping systems. Int. J. Agric. Biol., 18(4), 821–829.
171. Shukla, P. R., Skea, J., Calvo Buendia, E., Masson-Delmotte, V., Pörtner, H. O., Roberts, D. C., Zhai, P., Slade, R., Connors, S., Van Diemen, R. & Ferrat, M. (2019). IPCC, 2019: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Intergovernamental Panel on Climate Change (IPCC).
172. Šimon, T., & Czakó, A. (2014). Influence of long-term application of organic and inorganic fertilizers on soil properties. Plant Soil Environ. 60(7), 314–319. http://doi.org/10.17221/264/2014-PSE
173. Singh, D., Lenka, S., Lenka, N., Trivedi, S., Bhattacharjya, S., Sahoo, S., Saha, J., & Patra, A. (2020). Effect of reversal of conservation tillage on soil nutrient availability and crop nutrient uptake in Soybean in the Vertisols of central India. Sustainability, 12(16), Article 6608. https://doi.org/10.3390/su12166608
174. Singh, R., & Singh, G. S. (2017). Traditional agriculture: a climate-smart approach for sustainable food production. Energ. Ecol. Environ., Vol. 2(3), 296–316. https://doi.org/10.1007/s40974-017-0074-7
175. Soil Science Glossary Term Committee. (2008). Glossary of Soil Science Terms: 2008. Madison, WI: ASA-CSSA-SSSA. I. https://www.soils.org/publications/soils-glossary#

176. Song, X. H., Xie, K., Zhao, H. B., Li, Y. L., Dong, C. X., Xu, Y. C., & Shen, Q. R. (2012). Effects of different organic fertilizers on tree growth, yield, fruit quality, and soil microorganisms in a pear orchard. European Journal of Horticultural Science, 77(5), 204-210.
177. Sosa-Hernández, M. A., Leifheit, E. F., Ingraffia, R., & Rillig, M. C. (2019). Subsoil Arbuscular Mycorrhizal fungi for sustainability and climate-smart agriculture: A solution right under our feet?. Front. Microbiol., 10, Article 744. https://doi.org/10.3389/fmicb.2019.00744
178. Spann, T. M., & Schumann, A. W. (2010). Mineral nutrition contributes to plant disease and pest resistance. University of Florida, IFAS Extension, HS1181. https://edis.ifas.ufl.edu/hs1181
179. Stanek-Tarkowska, J., Czyż, E., Dexter, A., & Sławiński, C. (2018). Effects of reduced and traditional tillage on soil properties and diversity of diatoms under winter wheat. Int. Agrophys., 32(3), 403-409. https://doi.org/10.1515/intag-2017-0016
180. Stevenson, F., & Cole, M.(1999). The internal cycle of nitrogen in soil. In: M. Cole, F. Stevenson (Eds.). Cycles of Soils: Carbon, Nitrogen, Phosphorus, Sulfur, Micronutrients (2nd ed., pp.191–229). John Wiley & Sons, USA.
181. Stirling, G. R., Smith, M. K., Smith, J. P., Stirling, A. M., & Hamill, S. D. (2012). Organic inputs, tillage and rotation practices influence soil health and suppressiveness to soilborne pests and pathogens of ginger. Australasian Plant Pathol., 114, 99–112.
182. Tadesse, W., Bishaw,. Z. & Assefa, S. (2018). Wheat production and breeding in Sub-Saharan Africa Challenges and opportunities in the face of climate change. International Journal of Climate Change Strategies and Management, 11(5), 696-715. http://doi.org/10.1108/IJCCSM-02-2018-0015
183. Tagar, A. A., Adamowski, J., Memon, A. S., Do, M. C., Mashori, A. S., Soomro, A. S., & Bhayo, W. A. (2020). Soil fragmentation and aggregate stability as affected by conventional tillage implements and relations with fractal dimensions. Soil & Tillage Research, 197, Article 104494. https://doi.org/10.1016/j.still.2019.104494
184. Tallaksen, J., Bauer, F., Hulteberg, C., Reese, M., & Ahlgren, S. (2015). Nitrogen fertilizers manufactured using wind power: greenhouse gas and

energy balance of community-scale ammonia production. J. Cleaner Prod, 107, 626−635. https://doi.org/10.1016/j.jclepro.2015.05.130

185. Hassan, T. U., & Bano A. (2016). Biofertilizers: A novel formulation for improving wheat growth, physiology and yield. Pak. J. Bot., 48(6), 2233-2241.
186. Tayoh, L. N., Kiyo, L. M. I., & Nkemnyi, M. F. (2016). Chemical fertilizer application and farmers perception on food safety in Buea, Cameroon. Agricultural Science Research Journal, 6(12), 287 – 295.
187. Thirkell, T., Pastok, D., & Field, K. (2019). Carbon for nutrient exchange between Arbuscular mycorrhizal fungi and wheat varies according to cultivar and changes in atmospheric carbon dioxide concentration. Glob Change Biol., 26(3), 1725–1738. http://doi.org/10.1111/gcb.14851
188. Tshikunde, N. M., Mashilo, J., Shimelis, H., & Odindo A. (2019). Agronomic and Physiological Traits, and Associated Quantitative Trait Loci (QTL) Affecting Yield Response in Wheat (*Triticum aestivum* L.): A Review. Front. Plant Sci., 10, Article1428. http://doi.org/10.3389/fpls.2019.01428
189. Uthayakumaran, S. & Wrigley, C. (2017). Wheat: grain-quality characteristics and management of quality requirements. In: C. Wrigley, I. Batey, & D. Miskelly (Eds.), Cereal grains: assessing and managing quality. (pp. 91-134). Kidlington, United Kingdom: Woodhead Publishing (Elsevier).
190. Van Groenigen, K. J., Bloem, J., Bååth, B., Boeckx, P., Rousk, J., Bode´, S., Forristal, D., & Jones, M. B. (2010). Abundance, production and stabilization of microbial biomass under conventional and reduced tillage. Soil Biology & Biochemistry, 42(1), 48–55. https://doi.org/10.1016/j.soilbio.2009.09.023
191. Volkmar, K. (1996). Effects of biopores on the growth and N' uptake of wheat at three levels of soil moisture. Canadian Journal of Soil Science. 76(4), 453–458. https://doi.org/10.4141/cjss96-056
192. Wang, X., Wu, H., Dai, K., Zhang, D., Feng, Z., Zhao, Q., Wu, X., Jin, K., Cai, D., Oenema, O., Hoogmoed, W. B. (2012). Tillage and crop residue effects on rainfed wheat and maize production in northern China. Field Crops Research,132, 106–116. https://doi.org/10.1016/j.fcr.2011.09.012
193. Wasson, A. P., Chiu, G. S., Zwart, A. B., & Binns, T. R. (2017). Differentiating Wheat Genotypes by Bayesian Hierarchical Nonlinear Mixed Modeling of Wheat Root Density. Frontiers in Plant Science, 8, Article 282. http://doi.org/10.3389/fpls.2017.00282

194. Wei, X., Chen, J., Gao, B., & Wang, Z. (2020). Role of controlled and slow release fertilizers in fruit crop nutrition. In: A. K. Srivastava, & C. Hu (Eds.), Fruit crops: diagnosis and management of nutrient constraints (pp. 555–566). Elsevier, Amsterdam, .
195. Wery, J., Silim, S. N., Knight, E. J., Malhotra, R. S., Cousin, R. (1993). Screening techniques and sources of tolerance to extremes of moisture and air temperature in cool season food legumes. Euphytica, 73, 73–83. http://doi.org/10.1007/s10681-006-4723-8
196. Whitney, D. A., & Brown J. R. (Ed.). (1998). Recommended chemical soil test procedures for the North Central Region. North Central Regional Publ. 221 (revised). Univ. of Missouri.
197. Wolde, G. M., Mascher, M., & Schnurbusch, T. (2019). Genetic modification of spikelet arrangement in wheat increases grain number without significantly affecting grain weight. Molecular Genetics and Genomics, 294, 457–468.
198. Workayehu, T. (2010). Effect of Plowing Frequency and Weeding Methods on Weeds and Grain Yield of Wheat at Arsi Negelle, Ethiopia. East African Journal of Sciences, 4(2), 114-122.
199. Wu, X., Tang, Y., Lia, C., McHugh, A. D., Lia, Z., & Wua, C. (2018). Individual and combined effects of soil waterlogging and compaction on physiological characteristics of wheat in southwestern China. Field Crops Research, 215, 163–172. https://doi.org/10.1016/j.fcr.2017.10.016
200. Würschum, T., Leiser, W. L., Langer, S. M., Tucker, M. R., & Longin, C. F. (2018). Phenotypic and genetic analysis of spike and kernel characteristics in wheat reveals long□term genetic trends of grain yield components. Theoretical and Applied Genetics, https://doi.org/10.1007/s00122-018-3133-3
201. Wyngaard, N., Echeverrı´a, H. E., Rozas, H. R. S., & Divito, G. A. (2012). Fertilization and tillage effects on soil properties and maize yield in a Southern Pampas Argiudoll. Soil & Tillage Research, 119, 22–30.
202. Xu, J., Han, H., Ning, T., Li, Z., Lal, R. (2019). Long-term effects of tillage and straw management on soil organic carbon, crop yield, and yield stability in a wheat-maize system. Field Crops Research, 233, 33–40. https://doi.org/10.1016/j.fcr.2018.12.016
203. Yadavq, S., & Mishra, A. (2020). Ectopic expression of C4 photosynthetic pathway genes improves carbon assimilation and alleviate stress tolerance for

future climate change. Physiol Mol Biol Plants. 26, 195-209. https://doi.org/10.1007/s12298-019-00751-8.

204. Yagioka, A., Komatsuzaki, M., Kaneko, N., & Ueno, H. (2015). Effect of no-tillage with weed cover mulching versus conventional tillage on global warming potential and nitrate leaching. Agriculture, Ecosystems and Environment, 200, 42–53.

205. Yang, B., Wanga, P., You, D., & Liu, W. (2018). Coupling evapotranspiration partitioning with root water uptake to identify the water consumption characteristics of winter wheat: A case study in the North China Plain. Agricultural and Forest Meteorology, Vol. 259 pp: 296–304. https://doi.org/10.1016/j.agrformet.2018.05.017

206. Yang, H., Wu, G., Mo, P., Chen, S. H., Wang, S. Y., Xiao, Y., Ma, H., Wen, T., Guo, X., & Fan, G. (2020). The combined effects of maize straw mulch and no-tillage on grain yield and water and nitrogen use efficiency of dry-land winter wheat (*Triticum aestivum* L.). Soil Till. Res., 197, Article 104485. https://doi.org/10.1016/j.still.2019.104485

207. Ye, X., Lu, Q., Lu, Y., Liu, W,. Chen, G., Han, H., Zhang, J., Yang, X., Li, X., Gao, A., & Li, L. (2015). The effects of chromosome 6P on fertile tiller number of wheat as revealed in wheat-Agropyron cristatum chromosome 5A/6P translocation lines. Theor Appl Genet., 128, 797–811.

208. Yihdego, Y., Salem, H. S., & Muhammed, H. H. (2019). Agricultural pest management policies during drought: Case Studies in Australia and the State of Palestine. Nat. Hazards Rev., 20(1), http://doi.org/10.1061/(ASCE)NH.1527-6996.0000312

209. Yilmaz, H., Demircan, V., Gul, M. (2010). Examining of chemical fertilizer use levels in terms of agriculture environment relations and economic losses in the agricultural farms: The case of Isparta, Turkey. Bulg J Agric Sci., 16(2), 143–157.

210. Yoshioka, M., Iehisa, J. C. M., Ohno, R., Kimura, T., Enoki, H., Nishimura, S., Nasuda, S., & Takumi, S. (2017). Three dominant awnless genes in common wheat: finemapping, interaction and contribution to diversity in awn shape and length. PLoS ONE 12(4), Article e0176148. https://doi.org/10.1371/journal.pone.0176148

211. Zadoks, J. C., Chang, T. T., & Konzak, C. F. (1974). A decimal code for the growth stages of cereals. Weed Research, 14, 415-421. https://doi.org/10.1111/j.1365-3180.1974.tb01084.x
212. Zhang, Q., Song, Y., Wu, Z., Yan, X., Gunina A., Kuzyakov, Y., Xiong, Z. (2020). Effects of six-year biochar amendment on soil aggregation, crop growth, and nitrogen and phosphorus use efficiencies in a rice-wheat rotation. Journal of Cleaner Production, 242, Article 118435. https://doi.org/10.1016/j.jclepro.2019.118435
213. Zheng, Z., Parent, L. E., & MacLeod, J. A. (2003). Influence of soil texture on fertilizer and soil phosphorus transformations in Gleysolic soils. Can. J. Soil Sci., 83(4), 395–403. https://doi.org/10.4141/S02-073
214. Zulfqar, M. Siddique, S., Sehar U., Bin Mustafa H. S., Ejaz-ul-Hasan, & Sadaqat, H. A. (2016). Effects of climate change on field crops in the scenario of food security. Nature and Science, 14(7), 17-33.

ABSTRACT IN ARABIC:

الملخص باللغة العربية

مواءمة الممارسات الزراعية للتخفيف من آثار الجفاف على انتاج القمح (*Treticum aestivum* L.) في فلسطين

يعتبر القمح (*Treticum 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 الانتاج العالمي، إلا أنه يتناقص في بعض الدول نتيجة لعدد من العوامل أهمها الجفاف وسوء التوزيع المطري وارتفاع درجات الحرارة والعوامل المرتبطة بالتربة والجراد والصراعات البشرية.

في فلسطين، تتناقص إنتاجية القمح بشكل مطرد وذلك لعدة عوامل والتي تشمل الممارسات الزراعية الخاطئة وتدهور الاصناف والإجهاد الحيوي وكذلك التغير المناخي وتداعياته على وجه الخصوص. حيث يعتبر الجفاف وارتفاع درجات الحرارة من أهم العوامل المحددة لإنتاجية المحاصيل الحقلية في الشرق الأوسط عموماً بما في ذلك فلسطين. هذا ويوجد العديد من الاساليب والوسائل الزراعية المتبعة للتخفيف من أثر التغير المناخي وبالتالي زيادة انتاجية القمح والتي أهمها مواءمة أنظمة الحراثة والتسميد والتي ثبت انها الأكثر قابلية للتطبيق نظراً لسهولة إجرائها وقلة تكاليفها وإمكانية تنفيذها و/أو تجربتها ليس فقط من خلال العلماء والباحثين بل عن طريق المزارعين أيضاً الذين هم حجر الأساس في تغيير وتعديل ومواءمة الممارسات الزراعية المختلفة على مدى التاريخ البشري.

تهدف هذه الدراسة الى تقييم أثر ممارسات الحراثة والتسميد المختلفة على صفات القمح الشكلية ومكونات الانتاج الخاصة بالقمح وبالتحديد صنف الهيتيه الصفراء الذي يزرع بعلياً. ولتحقيق 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 2019/2018.

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

أظهرت الدراسة وجود فروقات معنوية بين المؤشرات المقاسة. حيث بينت النتائج أن الحراثة المختصرة أعطت وبفوارق معنوية الإنتاج الأعلى وطول الساق الأطول بالإضافة إلى أجود المواصفات في السبلات تليها نظام الحراثة التقليدية. أما بالنسبة للجزء الثاني فقد تفوقت الحراثة المختصرة عندما أضيف إليها زبل أغنام بمعدل 6

كوب للدونم في إنتاج البذور وعندما أضيف إلى الحراثة المختصرة 3 كوب زبل أغنام + سوبر فوسفات ثلاثي 12.5 كغم/دونم فقد أعطت أفضل إنتاج للقش.

بالإضافة الى ذلك، فقد هيمنت الحراثة المختصرة على ممارسات الحراثة الأخرى في جانب المواصفات الشكلية للقمح، والتي تعد مؤشراً مهما لاستجابة القمح للمعاملات المطبقة ولمدى تأقلمه مع ظروف الاجهاد. أيضاً فقد تبين في كلا الجزئين من التجربة أن الحراثة 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 الحراثة التقليدية منها في الحراثة المختصرة، إلا أن هذه الزيادة غير كافية لتغطية المصاريف الحراث المتكرر. أما فيما يتعلق بالأسمدة، فبشكل عام أظهرت معاملة زبل الأغنام بمعدل 6 كوب للدونم أعلى النتائج، متفوقة على كل معاملات التسميد الأخرى.

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

حقيقة، ولأغراض الزراعة الحافظة يتم الإبقاء على ما يقارب من 30% من مخلفات المحاصيل في الأرض، ولكن وبسبب انحسار المناطق الرعوية الناتج بسبب التغير المناخي والزحف العمراني والقيود الاسرائيلية، فإن رعاة الأغنام يضطرون لرعي مواشيهم في الحقول لتغذية هذه القطعان على مخلفات تلك المحاصيل.

لذلك فانه يوصى بتوعية رعاة الأغنام بفوائد ترك مخلفات المحاصيل في الارض والذي ينتج عنه من زيادة في الإنتاج.

إن هذه الدراسة -قصيرة المدى- ليست كافية وبشكل قطعي لتقييم أثر معاملات الحراثة والتسميد على القمح، ولكنها تعطي مؤشرات لممارسات واعدة للتكيف مع تبعات التغير المناخي، مما يستدعي مزيداً من البحث والدراسة على فترة أطول.