EEET ECOLOGICAL ENGINEERING & ENVIRONMENTAL TECHNOLOGY

*Ecological Engineering & Environmental Technology* 2023, 24(8), 172–180
https://doi.org/10.12912/27197050/171773
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Received: 2023.08.25
Accepted: 2023.09.15
Published: 2023.10.13

# Performance of Soft Wheat (*Triticum aestivum* L.) Under Two Management Systems 'No-Till' and 'Conventional' in a Low Rainfall Semi-Arid Mediterranean Area of Morocco

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**ABSTRACT**

The objective of this study is to evaluate the performance of soft wheat (*Triticum aestivum* L.) in farmers' fields under No-till farming compared to conventional farming with two management practices: 'Research recommended' vs 'Local farmers' practices. The study was conducted over a period of three cropping seasons in the Chaouia plain in Western Morocco, a Mediterranean semi-arid area with low rainfall. Trials were set up in a split-plot design with two factors: (1) management method (No-till vs. Conventional), and (2) practices (research recommended vs. Farmers' local practices), with four replications and were carried out at four farmers' fields (sites). Data collected included: stand density, canopy height, average number of tillers per plant, number of spikes per plant, biological yield, grain yield and harvest index. The results obtained show a significant effect of climatic years on the measured parameters. No-till system significantly improved yield components, canopy height, biological yield, and grain yield, particularly in dry years. No-till as practiced by farmers (C2) improved biological and grain yields, respectively, by 18 and 42% compared with farmers' current local practices (C1). These gains were, respectively, 83% and 142%, for the research recommended package under No-till, those of the research recommended package under conventional management (without direct seeding), were 61% and 81% for the biological and the grain yields, respectively. The harvest index increased from 27% under the current conventional farmers' local management (C1), to 31% with the research recommended package under the same management mode. Under No-till management, this index increased to 33% with local practices (C2) and 36% with the research recommended packages. No-till system can be a adaptative and resilient practice for wheat cultivation in the low rain fall semi-arid areas impacted by climate change, but farmers should consider the adoption of the whole No-till system, rather than limiting themselves solely to the zero-till seeder technique.

**Keywords:** semi-arid, cropping systems, soft wheat, No-till, Mediterranean agriculture, agricultural technology

## INTRODUCTION

Traditional agriculture, based on conventional practices such as soil ploughing, is often vulnerable to the effects of climate change. Crops and agricultural production systems were designed to respond to stable and predictable climatic conditions. However, with climate change underway, these traditional agricultural practices are no longer sufficiently resilient to meet current and future challenges (FAO, 2016). It is therefore crucial to explore new agronomic approaches that are sustainable and consider climate change and its effects on natural resources, crop yields and food security.

Agronomic alternatives such as conservation agriculture based on no-till farming offer solutions for adapting to climate change and building more resilient cropping systems. Direct seeding or no-till farming reduces soil erosion, improves water retention capacity, and promotes carbon sequestration, thus helping to mitigate the effects of climate change (Hatfield et al., 2001). Mediterranean rainfed areas are known for their water and heat stresses, where water loss through crop evapotranspiration exceeds the soil's capacity to absorb water as result of insufficient precipitations or rainfall irregularity, or by a low water storage capacity in the soil (Quiza et al., 2010). Water stress is one of the most important environmental stresses affecting cereal productivity and is a serious problem in many semi-arid regions, where rainfall varies from year to year and plants are subjected to more or less long periods of water deficit (Fathi and Barari, 2016). Moreover, water stress can be harmful depending on the stage at which it occurs, its intensity and duration, and the kind of species and variety grown (Abdelguerfi and Chebouti, 2000).

The effect of drought on emergence can have a positive effect on crop production in arid zones and arid seedbeds, due to the reduced number of plants per m² (Alahiane, 2020). This reduction in plant density could have negative effects on yield and its components (Beech and Leach, 1989). Dry matter production in many cereal species is negatively affected by lack of water and reduces dry matter accumulation (Shrestha et al., 2006). It also reduces the number of leaves and nodes, plant height and leaf area, and accelerates the rate of leaf senescence (Idrissi et al., 2012). Lack of water after flowering, combined with high temperatures, leads to a reduction in 1000-grains weight by altering grain filling speed and filling time (Triboï, 1990). During grain filling, lack of water results in a reduction in grain size (scalding), thus reducing yield (Gate et al., 1993).

Research on no-till in the rainfed semi-arid and arid zones of Morocco has concluded that the no-till production system will enable better adaptation to water deficit (Bouzza, 1992; Kacemi, 1992; Mrabet, 2000; and Huwe, 2003). They reported that the direct-seeding or zero-tillage system improves and stabilizes cereal production in these areas, conserves natural resources (soil and water), reduces production costs and improves water and fertilizer use efficiency (WUE).

The objective of this study is to evaluate the performance of soft wheat (*Triticum aestivum* L.) in farmers' fields under no-till farming compared to conventional farming with two management practices: Research recommended vs Local farmers' practices in a rainfed semi-arid low rainfall Mediterranean area of Morocco.

## MATERIALS AND METHODS

The agronomic trials were conducted in the cereal plain of Chaouia, Settat province, Morocco on Calcimagnesic soils. The climate of this plain is semi-arid Mediterranean type with annual average rainfall of 337 mm, with a mild winter (minimum between 3 and 5°C) and a hot summer (maximum between 35 and 41°C).

Research-recommended practices for soft wheat management were compared with farmers' local practices under two management modes: 'no-till system' and 'Conventional system that considers soil preparation' (Table 1). The management of soft wheat under the research recommended package included crop rotation with a short-cycle pea, the use of hessian fly resistant and short-cycle soft wheat variety 'Arrihane', the application of fertilizer at seeding at rate of 30–60–60 kg of N-$P_2O_5$-$K_2O$ as recommended by the Moroccan fertility map (www.ferimap.ma), sowing rate of 120 kg/ha with a combined seed drill during the first week of November, early chemical control of weeds followed by the application of 30 kg N/ha cover nitrogen at the tillering stage and another 30 kg N/ha at early heading stage, disease and insect control when needed.

In contrast to farmers' local practices, in conventional tillage (Control 1: C1) and no-till (Control 2: C2), the previous crop was an old variety soft wheat 'Achtar', the applied base fertilizer dose was 10–20–20 kg N-$P_2O_5$-$K_2O$, sowing at rate of 180 kg/ha t after the first significant rains by the 'end of November-early December). Weed control was applied only during rainy year (2020–2022) at the late tillering-early heading stage followed by the application of 20 kg N/ha of top-dressing nitrogen in favorable year only. No disease or insect treatments were applied (Table 1).

The trials were conducted in 4 sites (farms) with a two-factor split-plot experimental design with four replications in each site. These trials were monitored over a period of three cropping seasons: 2019–2020; 2020–2021 and 2021–2022. On each elementary plot (experimental unit), five plots of 1 m² were randomly sampled for agronomic data collection which covered: stand density, plant canopy height, tiller numbers per plant, spikes' number per plant, biological and grain yields and harvest index (grain yield/biological yield). All collected data were entered and organized, then analyzed using the multi-site, multi-year two-factor analysis of variance

**Table 1**. Crop management under no-till vs conventional and Research recommended vs Farmers' practices.

| Management methods (Main plot) | Practices (Sub-plot) | Soil preparation | Crop rotation | Fertilizers amounts. $N\text{-}P_2O_5\text{-}K_2O$ | Sowing date | Sowing amounts (kg/ha) | Weed control | N top dressing | Weed & insect control | Crop residue management |
|---|---|---|---|---|---|---|---|---|---|---|
| Conventional: with soil preparation | Recom-mended | Chisel + cultivator | Cereal/ legume | 30–60–60 | 1st week Nov | 120 | 3 leaves stage | 30 kg N/ha at tillering | yes | 30% left in the field |
| | Farmers' (C1) | Disc plow + disc harrowing | Cereal/ Cereal | 10–20–20 | Last week Nov | 200 | Late tillering/ elongation | 0 to 20 kg/ ha end elongation | No | Harvested and grazed |
| No-till: no soil preparation | Recom-mended | No plowing | Cereal/ legume | 30–60–60 | 1st week Nov | 120 | 3 leaves stage | 30 kg N/ha at tillering | Yes | 40% left in the field |
| | Farmers' (C2) | No plowing | Cereal/ Cereal | 10–20–20 | Last week Nov | 180 | Late tillering/ elongation | 0 to 20 kg/ ha end elongation | No | Harvested and grazed |

method (ANOVA) (SAS, 2011) and the smallest significant difference (LSD (5%) was used for mean comparison.

## RESULTS AND DISCUSSIONS

The three cropping seasons have experienced different rainfall amounts and trends for all sites. The first cropping season (2019–2020) received only 217 mm/year with high minimum, and maximum temperatures, whereas the second cropping season (2020–2021) was rainy with a total amount of 362 mm/year with a good distribution and a fairly warm winter. While the third cropping season (2021–2022) was dry with only 161 mm/year and severe water deficit throughout the season, accompanied by high temperatures, particularly in January and February. The late arrival of 60 mm of rains in March saved somewhat the cropping year by producing some total dry matter by small grain cereals. These climatic contrasts during the three years of experiment had remarkable effects on wheat crop performance under no-till and conventional management, as will be presented and discussed in the following section.

### The average soft wheat response

The average stand density and the average number of tillers/plant were similar for both no-till and conventional management methods, while average number of spikes/plant and canopy height were improved under no-till management ($P \leq 0.05$) (Table 2). Comparing practices under each management method, stand density was fairly high in the local controls, Control 1 and Control 2, for both direct-seeding and conventional management methods. This is due to the fact that farmers sow soft wheat at higher average rate of 180 kg/ha instead of the 120 kg recommended in improved practices. There was a significant improvement ($p \leq 0.05$) in tillering and canopy height under the recommended packages under both management methods, while the number of spikes/plant was remarkably improved under no-till (Table 2). Regarding the comparison between the two controls (C1 and C2) of the two management methods, we note that the farmers' no-till

**Table 2.** Response of soft wheat stand density, number of tillers/plant, number of spikes/plant and canopy height to two management modes: no-till and conventional seeding under Chaouia agro climatic conditions

| Management mode | Practices | Stand density (plants/m²)* | Tillers per plant* | Spikes per plant* | Canopy height (cm)* |
|---|---|---|---|---|---|
| Conventional | Recommended packages | 240,7 $^{b}$ | 1,6 $^{a}$ | 1,0 $^{a}$ | 44,2 $^{a}$ |
| | Local practices Control (C1) | 253,2 $^{a}$ | 1,3 $^{b}$ | 0,9 $^{a}$ | 35,3 $^{b}$ |
| | Means | 246,9 $^{a}$ | 1,5 $^{a}$ | 0,9 $^{b}$ | 39,7 $^{b}$ |
| No-till | Recommended packages | 244,6 $^{b}$ | 1,8 $^{a}$ | 1,3 $^{a}$ | 48,5 $^{a}$ |
| | Local practices Control (C2) | 252,5 $^{a}$ | 1,4 $^{b}$ | 1,1 $^{b}$ | 39,9 $^{b}$ |
| | Means | 248,6 $^{a}$ | 1,6 $^{a}$ | 1,2 $^{a}$ | 44,2 $^{a}$ |

**Note:** * Values with different letters are statistically different ($p \leq 0.05$).

(C2) improved slightly these agronomic parameters but not significantly.

### Biological yield, grain yield and harvest index

By switching from conventional to no-till management, average yields of total biomass and grain, as well as the harvest index rose respectively, from 2.351 to 2.705 kg DM/ha, from 688 to 940 kg/ha and from 29 to 35%. The no-till system achieved average increases of 15% for total biological yield mass, 37% for grain yield and 21% for harvest index (Table 3, Fig. 1, and Fig. 2).

Comparing farmers' local practices with the research recommended packages, under both management methods, we note that the later significantly improved ($p \leq 0.05$) biological and grain yields and harvest index. The respective gains achieved by the recommended packages are in the following order: 61.1 and 55.1% for biological yield, 81 and 70% for grain yield and 15 and 9% for harvest index, under conventional and no-till management modes, respectively (Table 3, Fig. 1, and Fig. 2).

Comparing the performance achieved to farmers' current local practices (C1), the introduction of no-till as practiced by farmers (C2) already improves ($p \leq 0.05$) the biological and the grain yields by 18% and 42% respectively. As for no-till practiced according to the research recommended packages, these gains rose to 83% for the biological yield and 142% for the grain yield, respectively. But when local practices are compared with research recommended package under conventional management (with soil preparation), these gains are of the order of 61% for total biomass and 81% for grain (Table 3, Fig. 1, and Fig. 2).

The harvest index was increased from 27% under current conventional local farmers' practices (C1), to 31% with the research recommended

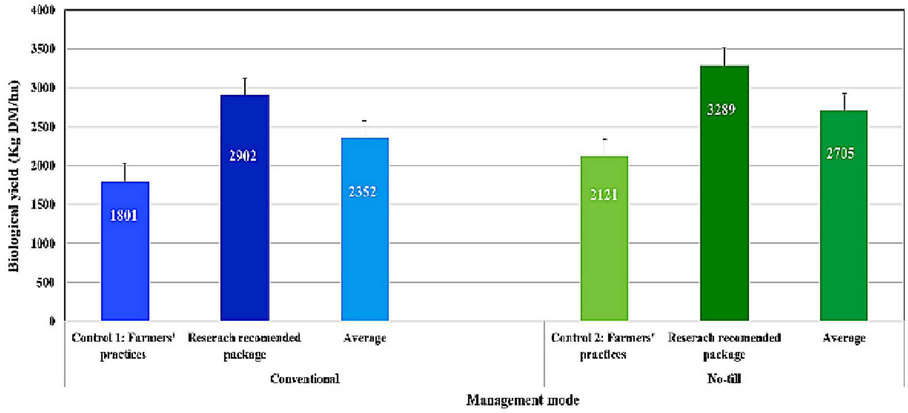


**Figure 1.** Effect of no-till farming on biological yield of soft wheat compared to conventional framing under Chaouia agroclimatic conditions

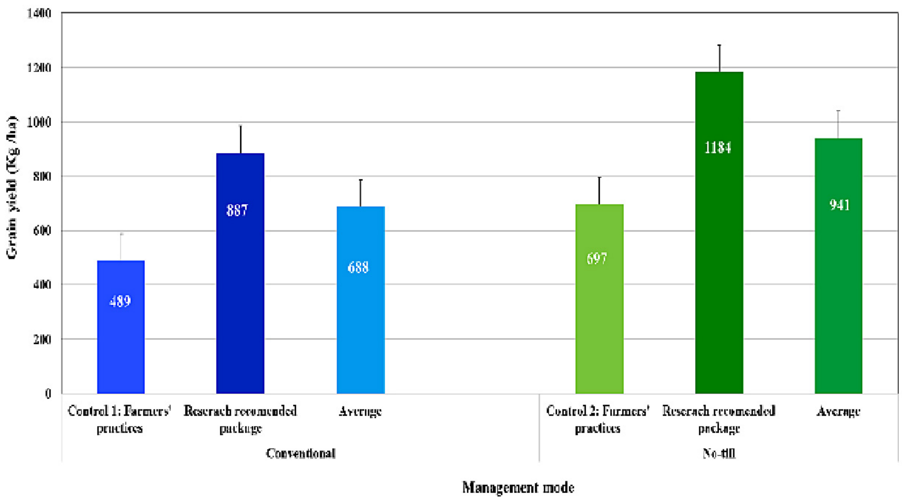


**Figure 2.** Effect of no-till farming on grain yield of soft wheat compared to conventional framing under Chaouia agroclimatic conditions

**Table 3** Response of soft wheat biological yields, grain yield and harvest index to two management modes: no-till and conventional seeding under Chaouia agro climatic conditions

| Management mode | Practices | Biological yield* (kg DM/ha) | Grain yield* (kg/ha) | Harvest Index* (%) |
|---|---|---|---|---|
| Conventional | Recommended packages | 2901[a] | 887[a] | 31 |
| | Local practices Control (C1) | 1801[b] | 489[b] | 27 |
| | Means | 2351[b] | 688[b] | 29 |
| No-till | Recommended packages | 3289[a] | 1184[a] | 36 |
| | Local practices Control (C2) | 2120[b] | 697[b] | 33 |
| | Means | 2705[a] | 940[a] | 35 |

**Note:** * Values with different letters are statistically different ($p \leq 0.05$).

package under the same management method. Under no-till management, this index was increased to 33% with local farmers' practices (C2) and up to 36% with the recommended packages (Table 3, Fig. 1, and Fig. 2).

## Soft wheat response to types of practice by growing season

The effect of growing seasons was significant ($p \leq 0.05$) on all variables observed, with the (2020–2021) season having the highest mean values followed by the (2019–2020) season and finally the (2021–2022) season (Table 4).

Comparing the average effect of the two management methods on the agronomic parameters observed, we note that no-till had a significant ($p \leq 0.05$) effect only on canopy height, which was improved in dry years but was slightly reduced in the average wet year, and on stand density, which was reduced in the wet year (Table 4).

During the first and third cropping seasons (2019–2020) and (2021–2022), which were dry to very dry, no significant differences were recorded on these agronomic parameters either between the conventional vs no-till management methods, or between the research recommended packages and the local controls (C1) and (C2) for

**Table 4**. Response of soft wheat stand density. number of tillers/plant. number of spikes/plant and canopy height to two management modes: no-till and conventional seeding and research recommended packages under Chaouia agro climatic conditions

| Cropping Seasons | Management mode | Practices | Stand density (plants/m²)* | Tillers per plant* | Spikes per plant* | Canopy height (cm)* |
|---|---|---|---|---|---|---|
| 2019–2020 | Conventional | Recommended packages | 224.0[a] | 0.9[a] | 0.2[a] | 30.6[a] |
| | | Local practices Control (C1) | 264.2[a] | 1.1[a] | 0.3[a] | 28.1[a] |
| | | Means | 244.1[a] | 1.0[a] | 0.3[a] | 29.4[b] |
| | No-till | Recommended packages | 237.3[a] | 0.9[a] | 0.2[a] | 37.3[a] |
| | | Local practices Control (C2) | 249.3[a] | 0.9[a] | 0.4[a] | 32.1[b] |
| | | Means | 243.3[a] | 0.9[a] | 0.3[a] | 34.7[a] |
| | Means | | 243.7[b] | 1.0[b] | 0.3[b] | 32.0[b] |
| 2020–2021 | Conventional | Recommended packages | 279.7[a] | 3.5[a] | 2.7[a] | 73.8[a] |
| | | Local practices Control (C1) | 283.4[a] | 2.6[b] | 2.2[b] | 64.6[b] |
| | | Means | 281.6[a] | 3.0[a] | 2.5[a] | 69.2[a] |
| | No-till | Recommended packages | 284.6[a] | 3.9[a] | 3.4[a] | 77.7[a] |
| | | Local practices Control (C2) | 237.7[b] | 2.3[b] | 2.0[b] | 53.2[b] |
| | | Means | 261.2[b] | 3.1[a] | 2.7[a] | 65.4[b] |
| | Means | | 271.4[a] | 3.1[a] | 2.6[a] | 67.3[a] |
| 2021–2022 | Conventional | Recommended packages | 218.4[a] | 1.0[a] | 0.5[a] | 42.8[a] |
| | | Local practices Control (C1) | 209.6[a] | 0.6[b] | 0.4[a] | 27.8[b] |
| | | Means | 214.0[a] | 0.8[a] | 0.4[a] | 35.3[b] |
| | No-till | Recommended packages | 211.9[a] | 1.2[a] | 0.7[a] | 46.8[a] |
| | | Local practices Control (C2) | 215.7[a] | 0.9[a] | 0.5[a] | 31.8[b] |
| | | Means | 213.8[a] | 1.0[a] | 0.6[a] | 39.3[a] |
| | Means | | 213.9[c] | 0.9[b] | 0.5[b] | 37.3[b] |

**Note:** * Values with different letters are statistically different ($p \leq 0.05$).

each management mode. However, during the rainy cropping season (2020–2021), the controls of the two management systems (C1) and (C2) had fewer tillers/plant, fewer spikes/plant and shorter canopy heights than the recommended packages (Table 4).

## Biological yield, grain yield and harvest index

Biological and grain yields varied significantly ($p \leq 0.05$) over years, with the highest yields recorded during the rainy season (2020–2021) averaging 4940 kg DM/ha and 1701 kg/ha, respectively, followed by the moderately dry season (2019–2020) with 1954 kg DM/ha and 626 kg/ha, respectively. The lowest yields were obtained in the severely dry season (2021–2022), which averaged just 1130 kg DM/ha of total biomass yield and 278 kg/ha of grain yield. Average harvest indices were also influenced by climatic year, with 34% for the rainy year, 32% for the moderately dry year and only 25% for the severely dry year (Table 5).

Regarding the effect of management method on average total biomass and grain yields over the years, we note that no-till made significant gains ($p \leq 0.05$) for the biomass and grain yields during dry years but produced significantly less biomass than conventional in wet years. In fact, during the 2019–2020 season, conventional seeding produced 1832 kg DM/ha of biomass and 515 kg/ha of grain, while no-till produced 2077 kg DM/ha and 737 kg/ha, with respective gains of 13.4 and 43.1%. Similarly, in the 2021–2022 cropping season, conventional seeding produced 910 kg DM/ha of biomass and 162 kg/ha of grain, while no-till produced 1351 kg DM/ha and 394 kg/ha, with respective gains of 48.5 and 143.2%. During the 2020–2021 rainy season, the conventional system produced 5140 kg DM/ha of biomass and 1668 kg/ha of grain, while no-till produced 4741 kg DM/ha and 1733 kg/ha, recording a loss of -7.8% in biomass and a gain of 3.9% in grain, respectively (Table 5).

The average harvest index was significantly improved ($p \leq 0.05$) by zero-till compared with conventional for the three consecutive years of experimentation. It rose from 28% up to 36% during the first season, from 33% up to 37% during the second season and from 18% to 19% during the third season (Table 5).

Comparing the effects of the recommended packages with the local controls (C1) and (C2) under the two types of management, we found

**Table 5.** Response of soft wheat biological yield, grain yield and harvest index to two management modes: no-till and conventional seeding and research recommended packages under Chaouia agro climatic conditions

| Cropping Seasons | Management mode | Practices | Biological yield (kg DM/ha)* | Grain yield (kg/ha)* | Harvest Index (%)* |
|---|---|---|---|---|---|
| 2019–2020 | Conventional | Recommended packages | 1984 $^a$ | 556 $^a$ | 28 |
| | | Local practices Control (C1) | 1679 $^b$ | 474 $^a$ | 28 |
| | | Means | 1832 $^b$ | 515 $^b$ | 28 |
| | No-till | Recommended packages | 2334 $^a$ | 871 $^a$ | 37 |
| | | Local practices Control (C2) | 1819 $^b$ | 603 $^b$ | 33 |
| | | Means | 2077 $^a$ | 737 $^a$ | 36 |
| | Means | | 1954 $^b$ | 626 $^b$ | 32 |
| 2020–2021 | Conventional | Recommended packages | 6358 $^a$ | 2165 $^a$ | 34 |
| | | Local practices Control (C1) | 3921 $^b$ | 1172 $^b$ | 30 |
| | | Means | 5140 $^a$ | 1668 $^b$ | 33 |
| | No-till | Recommended packages | 6749 $^a$ | 2523 $^a$ | 37 |
| | | Local practices Control (C2) | 2733 $^b$ | 942 $^b$ | 35 |
| | | Means | 4741 $^b$ | 1733 $^a$ | 37 |
| | Means | | 4940 $^a$ | 1701 $^a$ | 34 |
| 2021–2022 | Conventional | Recommended packages | 1330 $^a$ | 234 $^a$ | 18 |
| | | Local practices Control (C1) | 490 $^b$ | 90 $^b$ | 18 |
| | | Means | 910 $^b$ | 162 $^b$ | 18 |
| | No-till | Recommended packages | 1882 $^a$ | 552 $^a$ | 29 |
| | | Local practices Control (C2) | 820 $^b$ | 237 $^b$ | 30 |
| | | Means | 1351 $^a$ | 394 $^a$ | 29 |
| | Means | | 1130 $^c$ | 278 $^c$ | 25 |

highly significant increases ($p \leq 0.01$) in biological and grain yields achieved by the research recommended packages across the years. Biological gains were 18% and 28% for conventional and no-till respectively, in the first season; 62% and 147% in the second season; and 172% and 130% in the third season. Grain production gains were, respectively 18% and 45% for conventional and direct seeding respectively in the first season, 85% and 168% in the second season and 161% and 133% in the third season (Table 5).

Compared with farmers' current local practices under conventional management (C1) (Table 5), the following can be noted:

- The application of the research recommended packages under conventional management improved biological yield by 18 to 172% and grain yield by 18 to 161% in dry years, and by 62% for biomass and 85% for grain in wet years.
- The application of the research recommended package under no-till management improved the biological yield by 39% to 284% and the grain yield by 84% to 513% in dry years, and by 72% for the biological yield and 115% for the grain yield in wet years.
- The application of no-till as practiced by farmers (C2) improved the biological yield by 8% to 67% and the grain yield by 27% to 163%, in dry years, but recorded a loss of -30% in biomass and -20% in grain in wet years.

This last result is very important to consider because instead of expecting an improvement in productivity with no-till, after the third year of no-till farming, there was a loss due to repeated droughts and farmers' failure to respect conservation farming principles.

The harvest index was significantly improved under no-till whether accompanied by recommended packages or farmers' practices during all cropping years (Table 5).

Results obtained in our study on the performance of direct-seeded wheat under Chaouia conditions, confirm those reported by Bouzza (1990), Mrabet (1997), and Huwe (2003). This increase in yield is due to improvements in water use efficiency (Kacemi et al., 1995) and soil quality (Lal et al., 2007). Direct seeding recorded higher yields than conventional seeding even in drought years, but not in rainy years, which differs from some reported results (M'hedhbi, 1995) who claim that no-till performs less well than conventional seeding at the very start of its installation. This finding was observed in our case, but only in a favorable year for certain parameters such as biological yield, but not for other agronomic parameters such as tillering, spike production, grain yield and harvest index. The results reported by Mrabet (2001) who indicated a similarity in yields between conventional and direct seeding systems during the first 3 to 5 years of adoption and in favorable years, are quite similar to our results.

Concerning the improvement of wheat productivity, it has been improved under the no-till system, especially when the management of the crop is well reasoned through the right choice of the previous crop, the appropriate high-producing adapted variety, the well-reasoned management fertilizer uses and the integrated pest management. The improvement of productivity per mm of water consumed is reflected in this work by the higher wheat yields obtained, whether in biomass or in grains, and the improved harvest index, compared to conventional management and local controls (C1) and (C2).

According to Passioura (2006), water productivity, in the field, of well-managed, disease-free, water-limited cereal crops could reach 20 kg/ha/mm (grain yield per mm water used). In our case study, this productivity in the controls (C1) and (C2), is significantly lower than this, suggesting that major stresses other than water are involved, such as crop undernutrition, irrational soil and seedbed preparation, inappropriate sowing date and rate, weeds, disease, and insect attacks. In this case, the greatest advances will come from appropriate crop management, in addition to the choice of suitable species and cultivars. While it's clear that water productivity will be low in crops affected by disease, pests or weeds, there are also more understated aspects of crop management or the behavior of various cultivars that can have significant effects on productivity.

Water productivity depends not only on how a crop is managed during its lifetime, but also on how it fits into the management of a farm as a whole, both spatially and temporally (Passioura, 2004). Managing the use of rainwater by crops can generate off-site effects that lead to dryland degradation. The role of tillage has changed and is likely to continue to change as the benefits of no-till techniques become more widely appreciated. Hatfield et al. (2001) review many aspects of soil and stubble management that influence soil water balance by affecting infiltration and storage of water in the soil, as well as evaporative losses from the soil surface.

## CONCLUSIONS

Results of this study show that during its early stage of adoption, no-till improved stand density, average number of spikes per plant, canopy height, total biomass yield, grain yield and harvest index for soft wheat, especially in dry years. Compared with farmers' local practices, the research recommended packages resulted in significant increases in these parameters. The effect of no-till varies according to climatic conditions and farming practices. However, it is important to note that the practice and adoption of no-till by farmers has not been optimal, resulting in yield losses under certain conditions. No-till can be a beneficial practice for growing wheat in Chaouia region, but farmers should consider adopting the whole no-till system, rather than just the zero-till technique. Full adoption of direct seeding can significantly improve agronomic parameters and yields, even in dry years.

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