IMPACT OF IMPROVED CROP PRODUCTION TECHNOLOGIES ON ENHANCING BARLEY 
AND WHEAT PRODUCTIVITY UNDER RAIN-FED AREAS OF JORDAN

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ABSTRACT

Thirty seven on-farm trials in 2001/02 and 2002/03 growing seasons were conducted to demonstrate the 
beneficial effects of improved crop production technologies (ICPTs) on the productivity of barley and wheat 
over farmers' practices in arid and semi-arid regions of Jordan. The ICPTs were compared with the farmers' 
method in an area of one hectare in each of the farmers' fields for each treatment (i.e. ICPTs versus farmers' 
practices). The results showed significant differences for grain and straw yield and an increase in harvest 
index, indicating the positive influence of ICPTs on the farm economic return. Compared to farmers’ 
practices, ICPTs resulted in an increased mean income of 128.02 and 228.13 US$ ha⁻¹ for barley with a 
benefit-cost ratio of 1.98 and 1.79 for the application of ICPTs compared to 1.80 and 1.38 for farmers' 
practices in 2001/02 and 2002/03 growing seasons, respectively. Similarly, the mean income obtained from 
the ICPTs application in wheat was 182.27 and 133.84 US $ ha⁻¹ more than that resulted from farmers 
practices with a benefit-cost ratio of 3.25 and 2.18 for the ICPTs compared to 3.0 and 1.86 for farmers' 
practices in the first and second growing season, respectively. This additional income could substantially 
benefit small-scale farmers and improve their livelihoods in Jordan. The results from the current study 
indicate the potential benefits of ICPTs in enhancing barley and wheat yields, and as consequence increase 
net returns in the arid and semi-arid regions of Jordan.

Key words: barley, farmers' practices, grain yield, improved crop production technologies, straw, wheat.

1. INTRODUCTION

Barley and wheat are the principal crops of poor 
farmers in arid and semi-arid regions in Jordan with 
a very low productivity (1000 kg ha⁻¹). These 
regions represent 90% of the field crops total 
growing areas in Jordan (Anonymous, 2005). Barley 
is the predominant crop below 300 mm rainfall 
(Ceccarelli, 1987), while wheat is grown in more 
stable areas that receive more than 300 mm annual 
rainfall (Al-Rawashdeh and Abdel-Ghani, 2008).

Arid and semi-arid regions in Jordan are characterized by climatic variability, in terms of the 
amount and distribution of rainfall (Ceccarelli, 1987). Environmental stresses such as variable 
drought and occasional frost during the tillering 
stage are main causes for low productivity 
(Ceccarelli, 1987; Weltzien and Fischbeck, 1990). 
Drought is often accompanied by a relatively high 
temperature, which promotes evapotranspiration and 
hence accentuates its effects (Ceccarelli and 
Grando, 1991). Moreover, barley and wheat 
production are constrained by low soil fertility, pest 
problems, lack of adapted and high-yielding 
cultivars, un-appropriate agronomic management 
and low adoption of improved technology packages 
(Van Leur et al., 1989; Haddad et al., 2005; Al- 
Zyoud, 2007; Al-Rawashdeh and Abdel-Ghani, 
2008).

The productivity of barley and wheat could 
possibly be increased in drought prone-areas by 
using high yielding varieties coupled with improved 
technology packages (Haddad et al., 2005; Al- 
Rawashdeh and Abdel-Ghani, 2008). There are 
many management decisions that farmers can make, 
which affect water use efficiency and reduce risk of 
production in water deficit conditions (Haddad et 
al., 2005; Al-Rawashdeh and Abdel-Ghani, 2008). 
However, the effectiveness of these techniques
depends not only upon the amount, but also on the timing of precipitation and/or irrigation. In the last decade, national efforts were concentrated to increase wheat and barley productivity by adoption of improved technologies. Therefore, the objective of the current study was to present the effect of improved crop production technologies (ICPTs) in enhancing barley and wheat productivity in drought prone-areas of Jordan.

2. MATERIALS AND METHODS

On-farm demonstration trials (37 trials in total) were conducted in an area of one hectare during 2001/02 and 2002/03 growing seasons to demonstrate the beneficial effects of ICPTs on the productivity of barley and wheat compared to local cultivar with farmers’ practices. Details of on-farm demonstration trials in terms of sample sizes in each site are presented in Table 1. The trials were conducted in seven and four selected areas in 2001/02 and 2002/03 growing seasons, respectively. Ramtha, Karak (Ghweer) and Shoubak are arid sites, characterized by low (<300 mm) and erratic rainfall, and have barley as the dominant field crop. Irbid, Maddaba (Center and Dieban) and Karak (Rabba) are more stable areas, semi-arid with relatively moderate to high precipitation (300-450 mm annually), and suitable to cultivate a wide range of crops, especially wheat, barley and some legume crops. Soil samples were collected from farmers’ fields and analyzed for Nitrogen (N) and available phosphorus (P). The results indicate that all the soils were low in N (200-300 mg kg⁻¹ soil) and low to medium in available P (10-18 mg kg⁻¹ soil). The soils were alkaline (pH=7.5-8.0) with less than 1% organic matter and high calcium carbonate content (15-30%).

The ICPTs included seedbed preparation using duck foot plough, early planting (middle of November), growing improved cultivars (Rum for barley and Hourani 27 for wheat) using a seed rate of 100 kg ha⁻¹ with a mechanical seed drill that place seed at a uniform depth. Seeds were treated with Captan (3g kg⁻¹ seed) before planting. Di-Ammonium Phosphate (DAP) fertilizer was applied at a rate of 100 kg ha⁻¹ before planting plus 40 kg N ha⁻¹ top dressed at early tillering stage in the form of urea. Weeds were controlled using 2,4-D herbicide at the all locations when the plants were at the two to three leaf stage. One fungicide spray was applied at late tillering stage to control rusts and powdery mildew when necessary. On the other hand, the farmers’ method included a seed bed preparation using any available plough, late planting (middle of December), no seed treatment, using of old varieties (i.e. landraces), broadcasting seeding with a higher seeding rate (140 kg ha⁻¹), a fertilizer dose of 100 kg DAP ha⁻¹ applied as basal just before planting and no utilization of herbicides and/or manual weeding. All experiments were harvested with combined harvesters. Data were collected for the following traits: grain yield (kg ha⁻¹), straw yield (kg ha⁻¹) and Harvest Index (the proportion of grain to grain + straw).

In order to compare ICPTs with the farmers’ practices (i.e., two treatments) in each of the farmers’ fields, the paired t-test was used to assess whether the grain and straw yields obtained by the ICPTs and the farmers’ practices are significantly different. The economic viability of ICPTs over the farmers’ practices was calculated depending on prevailing prices of inputs and outputs. The return of investment using ICPTs and farmers’ practices was calculated using benefit-cost ratio method (Puste and Jana, 1995; Yadav et al., 1997).
3. RESULTS AND DISCUSSION

The grain and straw yield were found to be higher in 2001/02 than in 2002/03 growing seasons (Tables 2, 3, 4 and 5), which could be due to the higher amount of precipitation and the adequate distribution of rains during this season compared to 2002/03 growing season (Fig. 1). These results are in agreement with previous studies (e.g., De Ruiter and Brooking, 1993; Al-Rawashdeh and Abdel-Ghani, 2008), who reported that the amount and distribution of rainfall during plant development under rainfed conditions are critical for crop development and consequently, dry matter accumulation in grain and straw.

The ICPTs gave significantly higher barley grain yields in all the farmers’ fields tested. Application of ICPTs resulted in a mean grain yield of 2005 and 1353 kg ha\(^{-1}\) in 2001/02 and 2002/03 growing seasons, respectively, which are 122% and 171% higher than that obtained with farmers’ practices (Tables 2 and 3). In addition to the increase in grain yield, the ICPTs also resulted in 393 and 725 kg ha\(^{-1}\) more straw yield in barley over farmers’ practices in 2001/02 and 2002/03 growing seasons, respectively. Similarly, the application of ICPTs in wheat contributed to yield increases in grain yield by 126% and 114% and in straw yield by...
Table (2): Grain and straw yield, harvest index and economics of barley in on-farm trials (average of 13 trials) in the five on-farm demonstration sites during 2001/02 growing season.

<table>
<thead>
<tr>
<th>Cultivation method</th>
<th>Grain yield (kg ha(^{-1}))</th>
<th>Straw yield (kg ha(^{-1}))</th>
<th>Harvest index (%)</th>
<th>Cost of cultivation (US$ ha(^{-1}))</th>
<th>Net return (US$ ha(^{-1}))</th>
<th>Benefit cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved crop production technologies</td>
<td>2005 ± 221</td>
<td>3081 ± 474</td>
<td>39.42</td>
<td>543.14</td>
<td>530.29</td>
<td>1.98</td>
</tr>
<tr>
<td>Farmers’ practices</td>
<td>1644 ± 159</td>
<td>2688 ± 466</td>
<td>37.95</td>
<td>504.92</td>
<td>402.27</td>
<td>1.80</td>
</tr>
<tr>
<td>Difference</td>
<td>361*</td>
<td>393**</td>
<td>1.47</td>
<td>38.22</td>
<td>128.02</td>
<td></td>
</tr>
</tbody>
</table>

* and ** indicate significant (P<0.05) and highly significant (P<0.01) differences, respectively.

Table (3): Grain and straw yield, harvest index and economics of barley in on-farm trials (average of 7 trials) in the three on-farm demonstration sites during 2002/03 growing season.

<table>
<thead>
<tr>
<th>Cultivation method</th>
<th>Grain yield (kg ha(^{-1}))</th>
<th>Straw yield (kg ha(^{-1}))</th>
<th>Harvest index (%)</th>
<th>Cost of cultivation (US$ ha(^{-1}))</th>
<th>Net return (US$ ha(^{-1}))</th>
<th>Benefit cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved crop production technologies</td>
<td>1353 ± 249</td>
<td>3155 ± 469</td>
<td>30.01</td>
<td>505.31</td>
<td>398.87</td>
<td>1.79</td>
</tr>
<tr>
<td>Farmers’ practices</td>
<td>790 ± 104</td>
<td>2430 ± 373</td>
<td>24.53</td>
<td>455.46</td>
<td>170.74</td>
<td>1.38</td>
</tr>
<tr>
<td>Difference</td>
<td>563*</td>
<td>725**</td>
<td>5.48</td>
<td>49.85</td>
<td>228.13</td>
<td></td>
</tr>
</tbody>
</table>

* and ** indicate significant (P<0.05) and highly significant (P<0.01) differences, respectively.

Table (4): Grain and straw yield, harvest index and economics of wheat in on-farm trials (average of 11 trials) in the four on-farm demonstration sites during 2001/02 growing season.

<table>
<thead>
<tr>
<th>Cultivation method</th>
<th>Grain yield (kg ha(^{-1}))</th>
<th>Straw yield (kg ha(^{-1}))</th>
<th>Harvest index (%)</th>
<th>Cost of cultivation (US$ ha(^{-1}))</th>
<th>Net return (US$ ha(^{-1}))</th>
<th>Benefit cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved crop production technologies</td>
<td>3040 ± 321</td>
<td>4527 ± 303</td>
<td>40.17</td>
<td>493.04</td>
<td>1110.36</td>
<td>3.25</td>
</tr>
<tr>
<td>Farmers’ practices</td>
<td>2411 ± 264</td>
<td>4317 ± 231</td>
<td>35.84</td>
<td>465.00</td>
<td>928.09</td>
<td>3.00</td>
</tr>
<tr>
<td>Difference</td>
<td>629**</td>
<td>210NS</td>
<td>4.33</td>
<td>28.04</td>
<td>182.27</td>
<td></td>
</tr>
</tbody>
</table>

NS and ** indicate non-significant and highly significant (P<0.01) differences, respectively.

Table (5): Grain and straw yield, harvest index and economics of wheat in on-farm trials (average of 7 trials) in the three on-farm demonstration sites during 2002/03 growing season.

<table>
<thead>
<tr>
<th>Cultivation method</th>
<th>Grain yield (kg ha(^{-1}))</th>
<th>Straw yield (kg ha(^{-1}))</th>
<th>Harvest Index (%)</th>
<th>Cost of cultivation (US$ ha(^{-1}))</th>
<th>Net return (US$ ha(^{-1}))</th>
<th>Benefit cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved crop production technologies</td>
<td>1241 ± 132</td>
<td>2700 ± 339</td>
<td>31.49</td>
<td>365.60</td>
<td>431.34</td>
<td>2.18</td>
</tr>
<tr>
<td>Farmers’ practices</td>
<td>1087 ± 152</td>
<td>2047 ± 189</td>
<td>34.68</td>
<td>347.35</td>
<td>297.50</td>
<td>1.68</td>
</tr>
<tr>
<td>Difference</td>
<td>154*</td>
<td>653*</td>
<td>-3.19</td>
<td>18.25</td>
<td>133.84</td>
<td></td>
</tr>
</tbody>
</table>

* indicates significant (P<0.05) differences.

105% and 130% over farmer’s practices in 2001/02 and 2002/03 growing seasons, respectively. Moreover, high grain and straw yields in ICPT’s treatments were also reflected in higher harvest index values in both seasons for barley yield trials and in 2001/02 growing season in wheat yield trials, as compared to farmers’ practices treatment. The increased grain and straw yields with ICPTs were mainly due to early planting, the use of improved varieties, proper N application timing and rates and
the mechanical seeding with grain drill. Date of planting usually has a large effect on seed yield of wheat and barley in West Asia and North Africa. Previous experiments showed that early planting (i.e. planting before the first rainfall of the season) results in substantial yield increase over the late planting dates (ICARDA, 1984, 1987; Ketata, 1987). Much of the early planting advantage resulted from the extended period of the growth, allowing better utilization of moisture for a longer period of time, and consequently resulted in the improvement of several agronomical traits contributing to yield. Haddad et al. (2005) reported that with improved barley technology packages, crop yields increased at least two-fold; grain yield increased by 38% with improved cultivars and 51% with N fertilizer application. The second dosage of N fertilizer in form of urea, which was only applied in ICPTs treatment, probably gave substantial yield increases over that produced using farmers practices. Papakosta and Gagianas (1991) reported that N application in split doses increased the efficiency of N fertilizer use and consequently increased the mean value of grain and yield in wheat. It seems to be that weed control with 2,4-D in the ICPTs treatment has a considerable impact on weed management, which presumably reduces the competition of weeds with barley and wheat for nutrients, water, and light. According to Tanji and Regehr (1988), 2,4-D application could remove 66% of the weeds and reduce weed dry weight by 82%. Seeding with a mechanical seed drill could also result in significantly greater yields than broadcasting method because drill seeding produces a more uniform stand than broadcasting and helps in weed control (Turk and Tawaha, 2003). Similarly, studies on other crop species indicated the potential benefits of improved technology packages in enhancing kharif legumes, pearl millet, pigeonpea and sorghum yields and net returns in the dry regions (Jain et al., 1988; Ramakrishna et al., 2004; Ramakrishna et al., 2005; Reddy et al., 2007).

The economic viability of ICPTs over the farmers’ practices was calculated depending on prevailing prices of inputs and outputs (Tables 2, 3, 4, and 5). Using the mechanical seed drill in ICPTs led to minimize the cultivation cost by 11.7 US$ ha\(^{-1}\) in wheat and 9.5 US$ ha\(^{-1}\) in barley compared to farmers’ practices, since the broadcast seeding requires about 40% more seeds than drilling. The additional cost was 37.92 and 49.85 US$ ha\(^{-1}\) for barley and 28.04 and 18.02 US$ ha\(^{-1}\) for wheat in 2001/02 and 2002/03 growing seasons, respectively, (Tables 2-5) incurred due to the ICPTs as compared to farmers’ practices was mainly due to additional fertilization (i.e. additional N application during tillering stage), seed treatment and herbicide application. However, the ICPTs resulted in an increased mean income of 128.25 and 228.13 US$ ha\(^{-1}\) for barley with a cost-benefit ratio of 1.98 and 1.79 in 2001/02 and 2002/03 growing seasons, respectively (Tables 2 and 3). Similarly, using the ICPTs in wheat showed also an increased mean income of 182.27 and 133.84 US$ ha\(^{-1}\) and a benefit-cost ratio of 3.25 and 2.18 for the ICPTs compared to 3.00 and 1.86 for the farmers’ practices in 2001/02 and 2002/03 growing seasons, respectively (Tables 4 and 5). This additional income could substantially improve farmers’ livelihoods in the dry regions of Jordan. Puste and Jana (1995) reported that the yield attributes and seed yield of pigeonpea varieties were significantly influenced by P fertilization with a maximum benefit-cost ratio of 4.12. In accordance, Yadav et al. (1997) indicated that with the application of 100% recommended fertilizer; sole pigeonpea gave a benefit-cost ratio of 2.94.

In general, framers’ mean income was found to be higher in 2001/02 than 2002/03 growing season, which could be due to the poor rainfall distribution in 2002/03 compared to 2001/02 growing season at the demonstration sites. Moreover, the lack of rains in 2002/03 during tillering and early flowering stage might reduce the solubility of N, and consequently, the efficiency of N fertilizer use. Several reports indicated that the high inter-and intra-seasonal variation in terms of amount and distribution of rains under rain-fed conditions could limit the crops response to N (Garab et al., 1998; Lopez-Bellido et al., 2006; AL-Rawashdeh and Abdel-Ghani, 2008).

In the current study, the increased grain and straw yields with improved barley and wheat technology packages were due to selection of suitable cultivar, application of balanced nutrients at appropriate time in split doses, and carrying other cultural operations on time. The results from the study clearly bring out the potential benefits of the application of the ICPTs in enhancing wheat and barley grain and straw yields and net returns in the arid and semi-arid regions of Jordan.
4. REFERENCES


تأثير استخدام تكنولوجيا محصول المحصول المحصن على زيادة إنتاجية الشعير والقمح تحت ظروف المناطق المطرية في الأردن

محمد علي البدور - عادل حسن عبد الغني
قسم الإنتاج النباتي - كلية الزراعة - جامعة مؤتة - الكرك - الأردن

ملخص