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# Influence of wheat residue management on irrigated corn grain production in a reduced tillage system

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**Abstract**

Management of wheat (*Triticum aestivum* L.) residues for corn (*Zea mays* L.) planting is an important issue in southern parts of Iran where these two irrigated crops are consecutively grown. Concerns have been raised in recent years over the burning of the crop residues by farmers in these areas. A 2-year (2001–2002) field experiment was conducted as a randomized complete block design with three replications. The treatments consisted of irrigated corn planted, after burning wheat residues followed by conventional tillage (CT), after residue removal followed by CT, after soil incorporation of 0, 25, 50, 75, and 100% of residue followed by chisel plow, disk harrow, and row crop planter equipped with row cleaner. The CT operations consisted of mollboard plowing followed by two times disk harrowing. Treatments had significant effects on corn grain yield, biological yield, and leaf area index. The highest grain yield (15.73 t ha$^{-1}$) and grains per ear (709.3) were obtained when 25–50% of wheat residues were soil incorporated and the seeds were sown with planter equipped with row cleaner in both years as compared with conventional tillage practices. It is recommended that complete residue removal or burning should be avoided; hence for successful corn production after wheat, residue management techniques that reduce residue level in the row area should be implemented.


*Keywords:* Residue management; Soil conservation; Corn planting; Row cleaner

## 1. Introduction

Reduced growth and yield of corn in winter wheat residues has been reported (Schrieber, 1992; Lund et al., 1993), especially in heavy wheat residues (Cochran et al., 1982; Wicks et al., 1994). Reduced grain yield has been attributed to climatic conditions (Cochran et al., 1982; Chastain et al., 1995; Beyaert et al., 2002), soil pathogens (Jenkyn et al., 1995), nitrogen immobilization (Jessop and Stewart, 1983), phytotoxicity from decomposing surface residues (Putman, 1994), and/or poor seedling establishment (Lindwal and Anderson, 1977).

Soil conditions for reduced tillage can be improved with tillage modifications. Pierce et al. (1992) adopted a zone till system (in-row soil loosening with flutted coulters) and obtained higher corn yield than with no till wheat residue. Kasper et al. (1990) found that removal of residues from the center of the row increased corn grain yield compared with no-till without residue removal. Opoku and Vyn (1997) suggested that corn response in no-till systems after wheat mostly depended on residue level. Beyaert et al. (2002) indicated that converting no-till to a zone-till would not affect yield nor cause a serious grain yield reduction relative to conventional tillage. Licht and Al-kaisi. (2005) reported that corn emergence rate index was slightly higher in

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strip tillage than either no tillage or chisel plow. Reducing the amount of wheat residue with no-till also increased grain yield (Swanton et al., 1995). These studies indicate the potential for modifying the no till system for corn production. It seems that for improved seedbed conditions, it is more appropriate to use a residue management practice to reduce the residue level, especially in row practice to reduce the residue level, especially in row center (Opoku et al., 1997) and in irrigated crops which have heavy residues to improve seedbed conditions.

Coulter planters are used for drilling seeds in soils having penetration problems and covered with previous crop residues. Raoufat and Mahmoodieh (2005) introduced chisel plowing followed by a coulter planter (leaving 30% residue cover) as an alterative to conventional cropping systems, offering advantages for conservation farming and better crop establishment.

Crop residue burning for summer planting is a common practice in southern Iran. It makes land preparation for the next crop easier and helps control pests (Biederbeck et al., 1980). Since irrigated wheat crops have high residues after harvesting and time of corn planting is short, farmers tend to include tillage operations in their system. There are some chopped residues discharged from the combine that would cover the field and prevent planter movement in the soil. Therefore, farmers somehow have to either burn or preferably reduce the amount of residues by residue harvest or grazing. Tillage methods that incorporate residues into soil could improve productivity and retard organic matter decline. However, there is not enough information on long-term influences of residue management, particularly in clayey soils in Iran. The objective of this research was to determine the influence of irrigated wheat residue levels on corn, using a modified row crop planter in Doroodzan region of Fars province, one of the main wheat-corn growing areas in southern Iran.

## 2. Materials and methods

A 2-year (2000–2002) field experiment was carried out on two different winter wheat (cv. Falat) fields at Kushkak Agricultural Experimental Station, Shiraz University (52°46′E, 29°50′N, altitude 1650 m asl) on a clay loam Ramjerd fine, mixed mesic, Typic Calcixerpts soil with pH of 7.3 and electrical conductivity of 0.98 dS $m^{-1}$. The average irrigated wheat residues cover determined by random throwing of 0.25 $m^2$ frame after harvesting was 5.0 t $ha^{-1}$ in both years.

The experiment was conducted as a randomized complete block design with three replications. Seven treatments were arranged in which corn (cv. SC 704) was planted: (1) burning of wheat residues followed by CT, (2) complete residue removal followed by CT, (3) complete residue removal followed by chisel plowing, (4) soil incorporation at 25% wheat residue with chisel plowing, (5) soil incorporation at 50% wheat residue with chisel plowing, (6) soil incorporation at 75% wheat residue with chisel plowing, and (7) soil incorporation at 100% wheat residue with chisel plowing. Treatments 3–7 were disk harrowed and planted with planter equipped with row cleaner wheels. Treatments 1 and 2

Table 1
Effects of different sowing treatments on yield and yield components of corn for 2 years

| | Sowing treatment | | Grain yield (t $ha^{-1}$) | | | Grain per ear | | | Biological yield (t $ha^{-1}$)[a] | 1000-grain weight (g) | LAI[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2001 | 2002 | Mean | 2001 | 2002 | Mean | | | |
| 1 | Residue burning[c] | | 14.5b | 13.6bc | 14.0bc | 507b | 671a | 589ab | 28.1abc | 260a | 9.0a |
| 2 | Residue removal[c] | | 10.9c | 11.5cd | 11.2e | 503b | 483ab | 493c | 23.7c | 269a | 8.1a |
| | Residue incorporation[d] | | | | | | | | | | |
| 3 | 0% | 0 t $ha^{-1}$ | 14.5ab | 13.2c | 13.8bc | 538.b | 536ab | 537bc | 24.0c | 259a | 8.1b |
| 4 | 25% | 1.25 t $ha^{-1}$ | 15.3a | 16.4a | 15.8a | 730a | 689a | 709a | 30.8a | 282a | 8.6b |
| 5 | 50% | 2.50 t $ha^{-1}$ | 14.4ab | 15.4b | 14.9ab | 520bc | 591ab | 555bc | 28.1abc | 258a | 8.0b |
| 6 | 75% | 3.75 t $ha^{-1}$ | 13.3b | 12.6c | 12.9c | 497c | 505ab | 501bc | 29.7ab | 256 a | 11.7a |
| 7 | 100% | 5.00 t $ha^{-1}$ | 11.6c | 10.3d | 10.9d | 428c | 428b | 428.0c | 26.7bc | 257a | 8.8b |
| 1 | Year 2001 | | | | 13.5a | | | 531.9a | 26.1b | 256a | 8.8a |
| 2 | Year 2002 | | | | 13.3a | | | 557.6a | 28.4a | 270a | 9.1a |

Means of each column (for seven treatments) and for 2 years separately followed by similar letters are not significantly different (Duncan 5%).
[a] Total above ground dry matter.
[b] Leaf area index.
[c] Molboard plow followed by lister planter with no cleaner wheels.
[d] Chisel plow followed by disk harrow and planter with cleaner wheels.

were prepared by molboard plow, 2 times disk harrow, followed by lister planter with cleaner wheels (Table 1). In order to stablish appropriate amount of residue for each residue incorporated treatments, excess residues (both flat and standing) were removed to stablish specified treatment. For example for treatment 4, 3750 kg ha$^{-1}$ of pretillage residues (5.0 t ha$^{-1}$) were taken out of the plot and the remaining 25% incorporated. Row and plant spacings were 75 and 20 cm, respectively, expecting 66,667 plants ha$^{-1}$ (39.0 kg seeds ha$^{-1}$). It should be noted that only two planting units were mounted on the available toolbar to permit movement of the planter in the experimental plots.

The row cleaner units were similar to Dawn vertical row-cleaners (Dawn Company, 2001). Each row cleaner unit consisted of two wheels measuring 160 mm in diameter mounted on a specially designed plate. The cleaner units were mounted in front of furrow openers of a pneumatic single seed-type row crop planter to set residues aside and facilitate seed drilling. Preliminary field tests indicated that the angle between the two wheels should be 45° for optimum cleaning capacity (Matbooei, 2003). A camber angle of 5° was considered in each row cleaner unit to facilitate cleaner wheel rotation. The residue cleaning units were precisely adopted to skim the soil surface and remove uniform amounts of residue with minimal soil displacement in the row. The cleaner wheels were able to clean the row centers to a width of 8–10 cm provided high forward speed were maintained.

A three-bottom general purpose moldboard plow and a nine-shank mounted chisel plow were used to till the experimental plots. The working widths of moldboard and chisel plows were 105 and 270 cm, respectively. The tilling depth of both plows was limited to 25 cm.

Corn seeds were sown in plots each 6 m × 4 m in mid-July right after wheat harvest in both years. The fertilizer broadcast at sowing time consisted of 100 kg ha$^{-1}$ diammonium phosphate and 200 kg ha$^{-1}$ urea at six-leaf stage. Plots were irrigated weekly and uniformly by siphons. The pH and electrical conductivity of irrigation water were 7.3 and 1.2 dS m$^{-1}$, respectively. Weeds were mechanically controlled by hand.

Leaf area was measured for at least five corn plants of each plot by leaf area meter (Delta T Device, UK) at anthesis. The two central rows of each plot were harvested by hand in early November in both years to determine grains per ear, 1000-seed weight, biological and grain yields. Data were statistically analyzed for each year and combined for 2 years by M STAT C software (M Stat C, 1989). Means were separated by Duncan's Multiple Range Test at $p \leq 5\%$.

## 3. Results and discussion

Treatments had significant effects on corn grain and biological yields, grains per ear, and leaf area index (LAI) for both years (Table 1). Grain yield averaged for residue burning and removal was lower than average grain yield for residue treatments. This is in agreement with minimum tillage of Moyer et al. (2004) for irrigated sugar beet (*Beta vulgaris*. L.) after wheat, but contradictory to the findings of Bahrani et al. (2002) who reported that wheat residue burning and removal increased yield in a continuous wheat cropping system in the same area. Thousand grain weight was not significantly different among treatments. This parameter is a genetically determined factor and usually does not change by environmental and management factors as shown by Kasper et al. (1990).

Complete residue removal followed by chisel plow, disk harrowing, and planting with row cleaner planter maintained the yield level compared with the traditional practice of residue burning followed by molboard plowing. The alternative system could preserve soil microorganisms and prevent environmental pollution.

Residue removal followed by conventional tillage resulted in lower grain yield as compared with no



Table 2
Mean air temperature and rainfall values during the corn growing months at Kushkak Agricultural Research Station (Shiraz, Iran)

| Month | Temperature (°C) | | | Rainfall (mm) | | |
|---|---|---|---|---|---|---|
| | 2001 | 2002 | 1976–2001[a] | 2001 | 2002 | 1976–2001[a] |
| May–June | 23.5 | 22.5 | 16.7 | 0 | 0 | 1.1 |
| June–July | 28.1 | 25.9 | 20.9 | 0 | 0 | 0.7 |
| July–August | 26.8 | 26.2 | 24.3 | 0 | 0 | 1.2 |
| August–September | 25.0 | 23.2 | 22.0 | 0 | 0 | 0.1 |
| September–October | 20.0 | 19.8 | 18.9 | 0 | 0 | 3.3 |

[a] Unpublished data, Irrigation Science Department, College of Agriculture, Shiraz University, Shiraz, Iran.

residue under reduced tillage. Residue burning and no residue incorporation raise concerns about soil surface cover (30%) (McCarthy et al., 1993) for soil conservation. The grains per ear, biological and grain yields were significantly affected by wheat residue levels. Correlation coefficients between wheat residue incorporation levels and these parameters were −0.73, 0.26, and −0.65, respectively.

Treatments with 25 and 50% residue incorporated levels provided maximum grain yield in both years as compared with other treatments (Table 1). The highest grain yield obtained by incorporating 25–50% of wheat residues could also be attributed to the lower exposure of corn seedlings to the possible inhibitory chemicals released by heavier residues (Putman, 1994). There were no significant differences in grain yield, 1000-grain weight, grains per ear, and LAI in both years, However, biological yield was significantly higher in second year due to favorable climatic conditions for corn growth and development (Table 2). Plants showed no signs of diseases or nutrient deficiencies in either year.

When all wheat residues were incorporated, either their allelopathic effects reduced grain yield (Cochran et al., 1977; Einhellig and Leather, 1988), or the residue might have provided cooler conditions for early plant growth (Al-Darby and Lowery, 1987), and/or nitrogen might have been temporally immobolized and become unavailable for attaining optimum crop yield (Jessop and Stewart, 1983). When residues are not incorporated, seedlings can emerge later due to clayey soil of the area (Opoku et al., 1997). However, when residues were reduced to less than half, they could have decomposed earlier and rapidly made nutrients available under the relatively high summer temperatures of the region accompanied by irrigation. In similar conditions, Opoku et al. (1997) indicated that zone tillage significantly resulted in higher corn yield than no till systems where residues remained in the zone above the corn row in clayey soils.

Corn is usually planted with row crop planter without cleaner attachment in a conventional tillage system, but with row cleaner under reduced tillage. Although not measured, planting in the row free of previous crop residues would enhance crop emergence and higher grain yield is expected. It should also be noted that the standing and the flat residues not only affect spacing between two consecutive seeds but also affect seed placement depth which would result in lower emergence.

Therefore, it can be concluded that complete residue removal or burning is to be avoided due to concerns for reduced soil organic matter levels, environmental and soil erosion problems. If corn production is to be successful following wheat in a reduced tillage system, it is important to adopt tillage and residue management techniques that reduce residue levels in the row center and improve seedbed conditions. Farmers can successfully bale part of the previous residues and till the field with chisel plow followed by disc harrowing and plant with modified row crop planter.

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