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Effects of Press Wheel Weight and Soil Moisture at Sowing on Grain Yield

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Abstract: The rates of seedling emergence were varied by the combination effects of soil moisture and resulted compacted soil under dryland farming. This study investigated the effects of the combination of press wheel weight and soil moisture on wheat (*Triticum aestivum* L.) seedling emergence and crop establishment. Also soil physical properties of the seedbed including soil moisture and bulk density were recorded. The experiment was conducted at Andika area, which is located on the north of Misjid Solaiman, Khouzistan province, in Iran. A factorial complete block design was applied with three levels of soil moisture 7.1, 14.3 and 20.6% and four levels of press wheel weights which were 5.4, 8.3, 10.2 and 10.5 kg cm^{-1} of press wheel width. Also, the effects of different types of press wheels (rubber and metal type press wheels) and the effects of their weights on seedling emergence were evaluated. This rate was significantly higher ($p \leq 0.05$) where the combination of 14.3% soil moisture and the amount of 5.4 kg cm^{-1} width of press wheels were used. The rate of emergence was significantly lower ($p \leq 0.05$) where the combination of 20.6% of soil moisture and the amount of 10.5 kg cm^{-1} of press wheels were applied. The rate of 85% seedling emergence was the highest ($p \leq 0.01$) where 14.3% of soil moisture was determined, whereas the lowest seedling emergence was measured 60.5% where the amount of soil moisture was 20.6%. Also, the wheel weight of 10.5 kg cm^{-1} width of wheel showed the lowest seedling emergence compared to other weight was used. The variable and adjustable wheel weight related to the amount of available soil moisture was shown a better rate of seedling emergence compared to a fixed amount of press wheel weight.

Key words: Dryland farming, press wheel weight, soil moisture, soil properties

INTRODUCTION

The area of dryland farming in Iran is more than 10 million hectares which are mostly devoted to wheat (*Triticum aestivum* L.) barley (*Hordeum vulgare* L.) and legume crops.

In recent years it has become more necessary to improve sowing techniques through preferred seedbed preparation and early crop growth (Eskandari, 1999; Asoodar *et al*., 2000; Asoodar, 2001). Current systems of sowing put the seeds in soils without controlling the rate of press wheel weight and resulted in reduced seedling emergence (Tessier *et al*., 1988, 1991; Riethmuller, 1990, 1995; Rainbow *et al*., 1992, 1994). Also using the correct type of press wheels gave better crop emergence and establishment which is due to improve depth control and seed to soil contact (Rainbow *et al*., 1992).

Most of agricultural lands in Iran are under cultivation and it is not economical to extend or develop new cultivated lands for increasing crop yield (Seyedan, 2002). So, the efforts of agricultural scientists are on the effects of different seed varieties and the better way of using technology and new methods of crop cultivation. The role of using the innovated farm machinery is one of the important applications for increasing crop production (Stickler, 1962; Asoodar, 2001).

Press wheels are now often used with the aim to establish better seed bed conditions improve crop growth (Radford, 1986) and uniformity of sowing depth (Asoodar, 2001) and create small furrows on the top of planted seeds (Tessier *et al*., 1991) (this aspect becomes more important where sowing takes place in non-wetting soils to guide rainfall into the soil instead of running off).

Drilling performance is influenced by furrow openers, covering devices, operating speeds, soil physical properties and type of crops (Tessier *et al*., 1991; Riethmuller, 1995).

The use of press wheels which press the soil over the seeds and make available the supply of soil water might give 25-50% higher in speed of emergence, 10-15% better crop establishment and growth (Stickler, 1962; Radford, 1986; Rainbow *et al*., 1992; Rainbow and Yeatman, 1994).

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Whilst crop establishment tended to increase with the use of press wheels, the total dry matter or yield of wheat was not improved in some cases (Bligh, 1994), however, Rainbow *et al.* (1992) Rainbow and Yeatman (1994) showed 10-20% higher grain yield in Australia. Compacted soil resulted of using press wheels could restrict the rate of damage to the planted seeds by insects (Ward, 1992). The research at the state of Queensland, Australia, 2003 has shown the amount of press wheel weight is related to available soil moisture at the time of sowing. Lower rate for the light soils and a higher weight (5 kg cm^{-1} width of press wheels) for the heavy soils.

Soil bulk density is one of the soil physical properties that is used to assess the effect of drilling practices on soils. Bulk density was shown to be greater in top soil layers under direct drilling techniques compared with conventional tillage by many researchers (Ehlers *et al.*, 1983; Mielke *et al.*, 1986; Chang and Lindwall, 1992; Edwards *et al.*, 1992; Francis and Knight, 1993).

Few research reports have been presented on the use of different press wheel weight on cereals (Rovira, 1993; Rainbow and Yeatman, 1994). However, the comparison of different press wheel weight has not been found in the literature in South of Iran.

The field experiment investigated the combination effects of press wheel weights and soil moisture on wheat (*Triticum aestivum* L.) seedling emergence under dryland conditions. Soil physical properties of the seedbed including soil moisture and bulk density were recorded. This study also described and analyzed how seed placement and press wheel weight influence the response of emergence and early growth of crop seedlings to changes in seedbed conditions. These effects were specially evaluated under dryland conditions in 2003 growing season.

MATERIALS AND METHODS

The experiments were sown at Andika sites (49° 14′E and 32° 2′N), 60 km north of Misjid Solaiman, at an average altitude of 750 m. The soil used for the study was a silty clay which is representative of large area of arable land in the Khouzistan province in Iran. the climate is characterized by a cool and rainy winter and a hot and dry summer. Mean annual rainfall is 352 mm over 70% of rain falls between November and April. The average yearly temperature is 24.9°C. The lowest temperature was -4.6°C in January and the highest was +51.6°C in July. The cropping sequence was wheat, fallow, wheat in a 2-year rotation. A conventional moldboard plow with a 150 mm depth and a disc harrow were used for preparing soil before planting.

The experimental plots were 5 m wide, 15 m long and 1 meter apart which was allocated in 4128 m^2 (86×48 m). Four press wheel weights (5.4, 8.3, 10.2 and 10.5 kg cm^{-1} of press wheel width) referred to as P_1, P_2, P_3 and P_4, respectively and three soil moisture (7.1, 14.3 and 20.6% gravimetric soil moisture) referred to as W_1, W_2 and W_3, respectively, were plotted in a factorial Completely Randomized Block Design with three replicates using both seeders to sow wheat. The press wheel weight for one of the seeders was constant 10.5 kg cm^{-1}, but this weight on the other seeder was adjustable, between a minimum of 5.4 kg cm^{-1} and a maximum of 10.2 kg cm^{-1} of press wheel width by changing the length and load of a spring mounted on the top of press wheels.

The seeding machines were calibrated to sow wheat at the rate of 120 kg ha^{-1}. 100 kg ha^{-1} of Di-Ammonium phosphate fertilizer (DAP, 18% Nitrogen and 46% Phosphorous) was placed while sowing seeds at the same depth.

Soil measurements: Prior to sowing, 24 soil samples across the experimental site were taken at random locations and at 0-50 mm and 50-100 mm depth, using stainless steel sleeves to measure the initial soil bulk density (McIntyre, 1974; Koppi *et al.*, 1992; Barzegar *et al.*, 2003). The sleeves were pressed into the soil and carefully excavated so that a known volume of soil could be transported in air-tight containers to the soil laboratories. Soil moisture and soil bulk density were calculated after the samples were oven dried at 105°C for 48 h to determine the percentage of water (dry basis, kg kg^{-1}) and to calculate bulk density (ρ_b).

Also, The gravimetric water content of the experimental soil was measured from 0-100 mm depth before sowing and along the sowing lines after sowing and during seedling emergence for comparing the seeder effects on seedling emergence.

Soil moisture content (dry basis, % kg kg^{-1}) of all samples was calculated and determined using the following formula:

$$\theta = \frac{(W_w - W_{od})}{W_{od}} \times 100 \qquad (1)$$

Where, θ = % moisture content on the dry weight basis, W_w = Mass of wet soil (kg), W_{od}= Mass of oven dry soil (kg).

Soil bulk density from 0-50 and 50-100 mm for each treatment was measured immediately after sowing to calculate the weight effects on soil and it's relation to the seedling emergence.

The dry bulk density (ρ_b) was computed using the following formula:

$$\rho_b = \frac{M_{od}}{V_t} \quad (2)$$

Where, ρ_b = Dry bulk density of soil (Mg m^{-3}), M_{od} = Mass of oven dry soil (Mg) and V_t = Total volume of undisturbed sample (m^3).

Seedling emergence: To measure the seedling emergence rate and percentage, one meter long runs of two adjacent sowing lines (0.50 m^2) were selected for all treatments. The selection of measuring lines was made at random before any seedlings emerged. The number of emerged seedlings (coleoptile visible at the soil surface) was measured each day after the first seedling had emerged until most of the seedlings could be seen on the soil surface. The seedlings were numbered as a percentage of viable sown seeds, which was calculated to be equivalent to the number of seeds m^{-2}.

The number of emerged seedlings was counted each day from the time when the first coleoptile was visible at the soil surface. Two approaches were used to analyze the emergence data. In the first, the cumulative emergence (E) in percentage of the number of sown seeds (Nasr and Selles, 1995; Erbach, 1982). The number of plants was calculated as a percentage of seeds planted. The average distance between sowing seeds in rows to calculate the seedling emergence in percentage of seeds sown was computed using the following formula:

$$D_{(cm)} = \frac{\text{Mass of 1000 seeds (g)} \times 100}{G \times W \times K} \quad (3)$$

Where, D is the average distance between two adjacent viable seeds in cm in a row. G is the amount of available seeds in kg ha^{-1} (gross mass), W is the sowing row width in cm, which was 25 cm, K is a factor that shows the purity and viability of seeds in percentage and 100 is the conversion factor.

Speed of emergence: The coefficient of velocity of emergence (CV) described by Yadav *et al.* (1976), Erbach (1982) was calculated directly from the daily emergence counts. At the end of the seedling emergence period, the speed of emergence (CV) was calculated for each treatment. The CV values were used to compare plant emergence speeds among the sowing treatments. The CV evaluates the speed of emergence and shows how quickly seedlings emerged. When the emergence period is shorter, the CV shows a higher rate and when this period is longer, for reasons such as lack of soil moisture, deeper sowing or evidence of soil compaction on the sown seeds, the index shows a lower rate which is an indication of emergence delay and low rate of emergence. The CV was calculated by using the following formula:

$$CV = \frac{(N_1 + N_2 + N_3 + \ldots + N_n)}{(N_1T_1 + N_2T_2 + N_3T_3 \ldots + N_nT_n)} \times 100 \quad (4)$$

Where, CV is the coefficient of velocity of seedling emergence, N_1, N_2,..., N_n is the number of newly emerged seedlings and T_1... Tn is the number of days after sowing when the seedlings are emerged.

Grain harvesting and yield components: The plots were harvested and the amount of biomass and grain yield for each treatment were calculated. The effects of different press wheel weights were also evaluated by comparing the grain yield components.

RESULTS

The effects of soil water content at 0-100 mm depth and press wheel weights on soil bulk density, at 0-50 and 50-100 mm depth, seedling emergence and speed of emergence are shown in Table 1.

Soil bulk density at the experimental site, before sowing, at depth 0-50 and 50-100 mm were 1.34,

Table 1: The mean values of soil water content and press wheel weights on soil bulk density, seedling and speed of emergence

Treatments	Soil moisture (%)	Bulk density 0-50 mm depth (Mg m^{-3})	Bulk density 50-100 mm depth (Mg m^{-3})	Emergence (%)	Speed of emergence
Soil water content					
W_1	7.1	1.41c	1.46b	63.50b	9.71c
W_2	14.3	1.45b	1.50a	75.00a	11.17a
W_3	20.6	1.52a	1.52a	60.50c	10.11b
	Width (kg cm^{-1})				
Press wheel weights					
P_1	5.4	1.39b	1.49a	71.67a	11.24a
P_2	8.3	1.48a	1.48a	66.00b	10.44b
P_3	10.2	1.49a	1.50a	63.33b	9.64d
P_4	10.5	1.48a	1.50a	64.33b	10.00c

Note: Means followed by the same letter(s) within columns do not differ at (*p≤0.05) level of probability

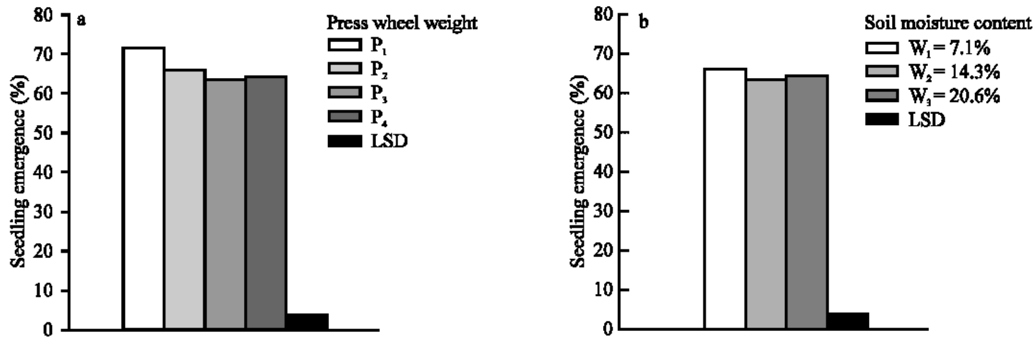

Fig. 1: Effects of four press wheel weights and three soil mistures on final seedling emergence

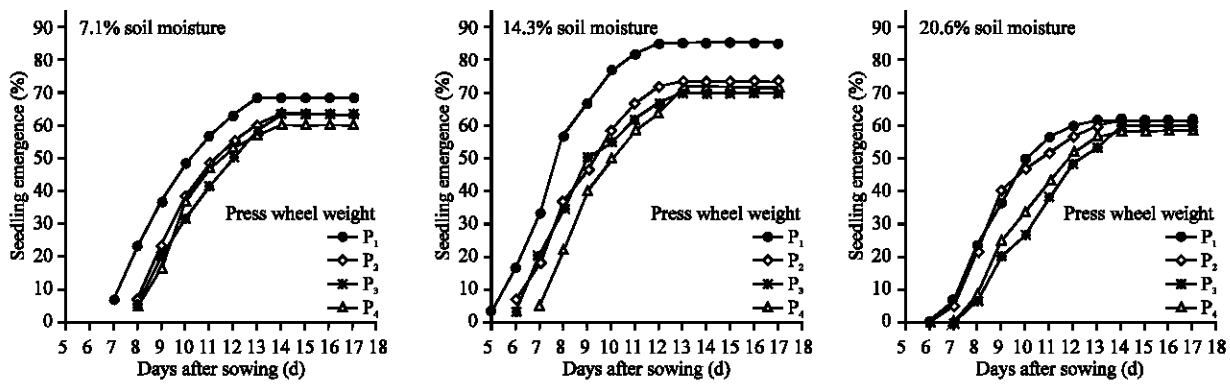

Fig. 2: Effects of soil moisture content and press wheel weight on seedling emergence rate

1.39 Mg m^{-3}, respectively. Soil bulk density, after sowing, at the depth of 0-50 mm was different, from 1.41-1.52 Mg m^{-3} and the range of soil bulk density from 50-100 mm depth was 1.46-1.52 Mg m^{-3}.

The effects of soil moisture and press wheel weights on in-row bulk density (Table 1) show the soil compaction at 0-50 mm depth increased ($p \leq 0.05$) by increasing the soil moisture and press wheel weights. Soil bulk density was also significantly lower at the depth 0-50 mm working with 7.1% soil moisture compared to 14.3% and 20.6% which were significantly ($p \leq 0.05$) increasing by higher soil moisture content (Table 1). At 50-100 mm depth, the soil bulk density shows to be higher ($p \leq 0.05$) with greater gravimetric soil moisture.

During the period from planting time to the day of measuring of final emergence, the soil became harder in all treatments. Planting techniques which were sowing seeds on different soil moisture and using four different press wheel weights had a statistically significant effect on seedling emergence (Fig. 1 and 2). The percentage of emerged plants with the treatment using the optimum soil moisture content (W_2, 14.3%) and the lowest press wheel weight was significantly higher ($p \leq 0.01$) compared to using the high (W_3, 20.6%) or low (7.1%, W_1) soil moisture content at sowing time (Fig. 1b). However the lower soil moisture content at seeding was significantly better than higher soil moisture, when the number of seedlings were compared.

Also, as shown in Fig. 1 and 2, increasing or decreasing soil moisture content at sowing time, from 14.3% significantly ($p \leq 0.01$) reduced seedling emergence. Present results are consistent with those reported by Tessier *et al.* (1991), Rainbow *et al.* (1994) and Finlay *et al.* (1994).

The speed of emerged seedling (CV) using 14.3% soil moisture (W_2) with a 5.4 kg cm^{-1} of press wheel width, was also significant (Table 1 and Fig. 2) compared to the W_1 and W_2 treatments. This might be due to the low soil compaction and easy available soil moisture around seed zone.

Grain yield and yield components: Table 2 shows the effects of soil moisture and press wheel weight on yield and it's components. The results were analyzed and the amount of harvested yield was significantly higher where the soil gravimetric moisture percentage was (14.3%) and the mean press wheel weight was about 5 kg cm^{-1} of press wheel width.

The results showed that grain yield was decreased where the soil moisture and press wheel weight increased

Table 2: The effects of soil moisture and press wheel weight on yield and it's components

Treatments	Soil moisture (%)	1000 grain yield	No. of seeds per head	No. of heads per m^2	Grain yields (kg ha^{-1})
Soil moisture					
W_1	7.1	38.93a	23a	211b	769b
W_2	14.3	35.50b	18.5b	256a	1002a
W_3	20.6	38.77a	20b	199b	693b
Press wheel treatments	Width (kg cm^{-1})				
P_1	5.4	38.17a	21a	230a	898a
P_2	8.3	38.74a	19a	226a	806b
P_3	10.2	38.86a	20.6a	194b	684c
P_4	10.5	37.9b	20a	206b	762b

Note: Means followed by the same letter(s) within columns do not differ at ($p \leq 0.01$*) or ($p \leq 0.05$) level of probability

at the time of sowing. Wheat crop yielded better where optimum moisture (W_2) was employed and lowest press wheel weights (P_1) was measured. The weight of grain one 1000 seeds was different and it found heavier where the seedling numbers were low.

DISCUSSION

The effects of soil moisture and press wheel weights on in-row bulk density (Table 1) show the soil compaction at 0-50 mm depth increased ($p \leq 0.05$) by increasing the soil moisture and press wheel weights, it might be due to the relationship between the increasing soil moisture can increase the soil compaction. McKeys (1985) and Tessier *et al.* (1991) found the same results of higher soil compaction resulted between 10-15% soil moisture content. The soil bulk density, after sowing, at the depth of 0-50 mm was different, from 1.41-1.52 Mg m^{-3} and the range of soil bulk density from 50-100 mm depth was 1.46-1.52 Mg m^{-3}.

At 50-100 mm depth, the soil bulk density shows to be higher ($p \leq 0.05$) with greater gravimetric soil moisture, this might be due to the combination effects of higher soil moisture and bigger amount of wheel weight on sowing lines which is similar to Bligh (1994) and Rovira (1993) findings. However, this moisture did not affect on soil compaction at 50-100 mm depth.

Present results also were supported by Yadav *et al.* (1976), Erbach (1982) and Rainbow *et al.* (1994) findings. Wheat grain yields gave the highest response to 5.4 kg cm^{-1} of press wheel width (P_1) and 14.3% (W_2) soil moisture content on seeding zone, the same relationship between press wheel weight and soil moisture content were presented by Finlay *et al.* (1994) and also Tessier *et al.* (1991). If this combination of soil moisture and press wheel weight, could be controlled at sowing (Radford, 1986), it could prepare the best condition for seedling emergence (Baker, 1986) and crop growth and yields (Riethmuller, 1995). However the lower soil moisture content at seeding had significantly better effects than higher soil moisture, when the number of seedlings were compared, it might be due to the effects of excessive compacted soil resulted by increasing soil moisture on sown seeds. Our results were consistent with those reported by Tessier *et al.* (1988; 1991), Rainbow *et al.* (1994), Finlay *et al.* (1994) and Radford *et al.* (1995).

The amount of soil moisture contents and press wheel weights at the time of sowing not only had significant effects on soil bulk density over the seed zone area ($p \leq 0.05$) and the percentage of emerged plants ($p \leq 0.01$), but also, on the yield production. The "P_1" and "P_2" using optimum moisture content at sowing times had higher speed of seedling emergence, it might be due to reduced soil compaction and resulted better moisture movement for the use of seedlings. Therefore the lower weight from press wheels could produce the optimum soil compaction with the highest seedling emergence rate. Both soil moisture treatments at depth of 0-100 mm and the press wheel weights had shown to be important at the time of sowing under dryland farming conditions. Also, as shown in Fig. 1 and 2, increasing or decreasing soil moisture content at sowing time, from 14.3% significantly ($p \leq 0.01$) reduced seedling emergence and resulted grain yields.

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