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Performances of Wheat under Irrigated Bed Planting System in Semiarid Iran

Kazem Moradi and Somaye Mirzaey
Department of Agronomy, Faculty of Plant Breeding,
Agriculture and Natural Resources University, Kodestan, Iran

Abstract: Bed planting systems are gaining importance in various environments worldwide. In this research which started in 2003, the objective is to adopt the bed planting systems to irrigated conditions of semiarid Iran in order to intensify wheat production. In here, the Bed Planting System (BPS) is contrasted to Flat Planting System (FPS) based on primary and seedbed preparation for seeding wheat. We also applied two different varieties of bread and durum wheat to evaluate their Water Use Efficiency (WUE) and productivity. The research was conducted in two distinct Sites (Sidi El Aydi and Affourar). The results showed higher overall wheat performances (WUE and grain yield) in 2004 and 2005 at Sidi El Aydi site compared to Darab. Wheat performed equally between BPS and FPS in the two sites. However jawher and karim, a durum wheat variety was the most productive and water use efficient under BPS. Due to the significance of interaction wheat variety x planting system, the experiment should be conducted for longer period and a larger set of varieties of wheat need to be studied in order to select those appropriate for the bed planting systems in semiarid Iran.

Key words: Bed planting, varieties, wheat productivity, water use efficiency, irrigation, semiarid Iran

INTRODUCTION

In Iran, agriculture represents between 15-20% of gross domestic product depending on rainfall and employs 50% of active population. The agricultural land area has varied from 8 millions ha in 1970s to 9 millions ha in 2000 which represents 12% of total land areas. The greatest part (87%) of these lands is located in rainfed zone. However, although irrigated zones constitute 13% of agricultural lands, they contribute to approximately 45% of the agricultural earnings. In fact, the development of Moroccan agriculture and economy was based on the last 3 decades on maximizing capture of surface water resources and optimizing their use for irrigated lands.

Cereals are dominant crops in irrigated areas covering 250,000 ha. Traditional surface irrigation techniques are still the preferred irrigation schemes by farmers (Essafi and Vidal, 2000). Moreover, vis-a-vis the reduction in hydraulic resources and their fluctuation over the years, the introduction of more efficient and less expensive techniques are essential. Among the systems of irrigation gaining momentum in several countries is irrigation with bed planting. The great success which had this technique in Yaqui Valley (North of Mexico) encouraged us to test this new technology under the Moroccan conditions. Indeed, the bed planting system offered opportunity for initial weed control prior to planting, facilitates access to crop for timely nutrient (especially N) application, reduced crop lodging, uses lower seed rate, reduced herbicide dependence, allowed better stand establishment, reduced soil erosion by irrigation water if crop residues are left on the surface in furrows, reduced field compaction by restricting machinery traffic (Hobbs *et al*., 1998; Reeves *et al*., 1999; Sayre and Hobbs, 2004). The introduction of this technique in North Mexico had improved the wheat grain yield by at least 10% and water economy by up to 35% in comparison with the conventional system (Aquino, 1998). The research studies completed on this system of sowing showed that the varieties which were used in the case of conventional sowing are not inevitably those which adapt to sowing in bed planting system. Thus, the objective were to test for the first time in Iran the technique of sowing in bed planting and to evaluate among the Moroccan varieties in irrigated conditions those which adapt the best to this technique.

MATERIALS AND METHODS

The experiment was conducted during 2003-2004 and 2004-2005 in two research sites at the Institut National de la Recherche Agronomique (INRA). The first site, Sidi El Aydi experimental station is located 145 km South of Fasa, in Fars region, Iran. The second site, Darab experimental station is located 18 km south of Beni Mellal in Tadla region, Iran. Both stations are located in semiarid area of Iran with the growing-season precipitation not exceeding 250 mm in average.

Corresponding Author: Kazem Moradi, Plaque 50 Alley 209 Mahdeh, Clinic Hamzeh Side, Fasa, Fars, Iran

The experimental design was a split-plot with three replicates. Individual plot size was 9×13 m. Planting methods (bed and flat) were the main plots and four winter wheat varieties (two durum wheat varieties: Karim and Jawhar and two bread wheat varieties: Chamran and Roshan) were the sub plots. The flat plots were sown at 20 cm row spacing with a Wintersteiger seed drill and the bed plots were sown by hand because we did not have a specific bed planter. There were two rows per bed spaced 20 cm on the top of each bed. The sowing was done on December, 26 in Sidi El Aydi and January 04, 2003 in Darab for growing season 2003-2004. The sowing date in Darab was delayed because the high rain in November and December prevented machinery from entering the field for land preparation and planting. In the second season (2004-2005), the sowing was done on November 21, 2003 in Sidi El Aydi and December 25, 2003 in Darab. Following soil test recommendations, no K fertilizer was necessary. At seeding, triple superphosphate at rate of 100 kg ha^{-1} and Ammonium Sulphate at rate of 200 kg ha^{-1} were supplemented to wheat.

During wheat growth, urea (100 kg ha^{-1}) was applied by hand at early tillering and at first node stage, on the bed surface between the rows in the bed plots and broadcast in the flat plots. Five irrigations were given at sowing, tillering, stem elongation, heading and grain filling. All treatments received the same amount of water during irrigation.

Total Dry Matter (TDM) and Grain Yield (GY) were recorded from hand samples taken from two 1×1 m quadrants of each plots. Grain Water Use Efficiency (WUEg) was calculated from Crop Water Use (CWU) and Grain Yield (GY) as below:

$$WUEg = GY/CWU$$

Where:

GY = Grain Yield

$$CWU = P + I + \Delta SW$$

Where:

P = Precipitation between sowing and harvest

I = Irrigation

ΔSW = Soil water depletion between sowing and harvest

Treatment effects were compared using an analysis of variance.

RESULTS AND DISCUSSION

Effect of planting methods on wheat grain yield: The analysis of variance showed significant differences between sites and years. Grain yield obtained in 2004-2005 was significantly higher compared to those of 2003-2004 season (Table 1 and 2). In both growing seasons, the mean grain yield in Sidi El Aydi was higher compared to Darab. Wheat grain yield ranged from 5.72-8.48 ton ha^{-1} in Sidi El Aydi and from 4.46-7.00 ton ha^{-1} in Darab. The lowest grain yield obtained in Darab site resulted from the very late sowing date and low soil surface drainage in 2003-2004 growing season.

In spite of the non significant difference between the planting methods, the comparison between the two planting methods showed that the mean grain yields of bed planting were slightly higher than those of flat planting. For both growing seasons, the mean grain yield for bed planting was 7.02 ton ha^{-1} against 6.76 ton ha^{-1} for flat planting.

The grain yield response to planting method tended to be associated with the variety used. They are also significant interaction between variety and planting method in Sidi El Aydi site. Many researchers reported similar results (Sayre and Moreno, 1997; Hobbs *et al*., 1998). Table 1 and 2 show grain yield for Sidi El Aydi and Darab sites for two durum wheat varieties (Karim and Jawhar) and two bread wheat varieties (Chamran and Roshan). In bed planting system, the highest mean grain yields were obtained by durum wheat varieties (Karim and Jawhar). The variety Jawhar perform well with bed

Table 1: Effect of planting methods on grain yield (ton ha^{-1}) for four wheat varieties in Sidi El Aydi

Planting methods	Varieties	2003-2004	2004-2005	Mean
Bed	Karim	6.99^{a}	8.17^{a}	7.58
	Jawhar	6.97^{a}	8.48^{a}	7.72
	Chamran	5.97^{b}	7.07^{b}	6.52
	Roshan	6.00^{b}	6.54^{b}	6.27
Flat	Karim	6.68^{a}	7.57^{a}	7.12
	Jawhar	5.72^{b}	6.80^{b}	6.26
	Chamran	6.01^{b}	7.81^{a}	6.91
	Roshan	6.37^{b}	7.19^{b}	6.78^{NS}
Mean	Bed planting method	6.48	7.56	7.02
	Flat planting method	6.19^{NS}	7.34^{NS}	6.76^{NS}

Values in the same columns followed by the same letter are not significantly different (LSD test: $p \leq 0.05$)

Table 2: Effect of planting methods on grain yield (t ha^{-1}) for four wheat varieties in Darab

Planting methods	Varieties	2003-2004	2004-2005	Mean
Bed	Karim	4.92	6.80	5.86
	Jawhar	4.88	7.00	5.94
	Chamran	5.17	6.45	5.81
	Roshan	5.00	6.23	5.61
Flat	Karim	4.96	6.29	5.62
	Jawhar	4.46	6.05	5.25
	Chamran	5.07	6.96	6.01
	Roshan	4.95^{NS}	6.09^{NS}	5.52^{NS}
Mean	Bed planting method	4.99	6.62	5.80
	Flat planting method	4.86^{NS}	6.34^{NS}	5.60^{NS}

NS: Not Significant (LSD test: $p \leq 0.05$)

Table 3: Effect of planting methods on total dry matter (ton ha^{-1}) for four wheat varieties in Sidi El Aydi

Planting methods	Varieties	2003-2004	2004-2005	Mean
Bed	Karim	14.94	17.59	16.26
	Jawhar	14.68	17.53	16.10
	Chamran	13.21	16.07	14.64
	Roshan	12.42	16.86	14.64
Flat	Karim	14.44	15.71	15.07
	Jawhar	13.05	17.00	15.02
	Chamran	13.81	17.27	15.54
	Roshan	14.29^{NS}	13.09^{NS}	13.69
Mean	Bed planting method	13.81	17.01	15.41
	Flat planting method	13.89^{NS}	15.77^{NS}	14.83^{NS}

Table 4: Effect of planting methods on total dry matter (ton ha^{-1}) for four wheat varieties in Darab

Planting method	Varieties	2003-2004	2004-2005	Mean
Bed	Karim	10.60	17.92	14.26
	Jawhar	11.40	16.06	13.73
	Chamran	12.68	17.72	15.20
	Roshan	11.66	16.90	14.28
Flat	Karim	11.21	15.56	13.38
	Jawhar	10.93	15.22	13.07
	Chamran	13.03	16.61	14.82
	Roshan	11.14^{NS}	15.38^{NS}	13.26
Mean	Bed planting method	11.59	17.15	14.37
	Flat planting method	11.58^{NS}	15.69^{NS}	13.63^{NS}

NS: Not Significant (LSD test: $p \leq 0.05$)

Table 5: Effect of planting methods on grain water use efficiency (WUEg) (kg/ha/mm) for four wheat varieties in Sidi El Aydi

Planting methods	Varieties	2003-2004	2004-2005	Mean
Bed	Karim	22.17^{a}	19.57^{a}	20.87
	Jawhar	22.10^{a}	20.31^{a}	21.20
	Chamran	18.92^{b}	16.94^{b}	17.93
	Roshan	19.03^{b}	15.66^{b}	17.34
Flat	Karim	21.16^{a}	18.14^{a}	19.65
	Jawhar	18.01^{b}	16.28^{b}	17.14
	Chamran	19.03^{b}	18.71^{a}	18.87
	Roshan	20.20^{b}	17.24^{b}	18.71
Mean	Bed planting method	20.55	18.12	19.33
	Flat planting method	19.60^{NS}	17.59^{NS}	18.59^{NS}

Values in the same colums followed by the same letter are not significantly different (LSD test: $p \leq 0.05$): NS: Not significant

Table 6: Effect of planting methods on grain water use efficiency (WUEg) (kg/ha/mm) for four wheat varieties in Darab

Planting methods	Varieties	2003-2004	2004-2005	Mean
Bed	Karim	13.03	18.43	15.73
	Jawhar	12.31	18.96	15.63
	Chamran	14.32	17.46	15.89
	Roshan	13.25	16.89	15.07
Flat	Karim	13.15	17.04	15.09
	Jawhar	11.29	16.38	13.83
	Chamran	13.96	18.83	16.39
	Roshan	13.12	16.48	14.80
Mean	Bed planting method	13.22	17.93	15.58
	Flat planting method	12.88^{NS}	17.18^{NS}	15.03^{NS}

NS: Not Significant (LSD test: $p \leq 0.05$)

planting and permitted the highest grain yield (8.48 ton ha^{-1}) but under the same condition it presents a significant yield depression when planted on flat. The variety Karim showed more stable grain yields across both planting methods. Sayre and Moreno (1997) also reported important genotype x bed planting interaction.

Effect of planting method on total dry matter: Total dry matter was significantly affected by growing season. In both experimental sites (Sidi El Aydi and Darab), the highest total dry matter was obtained in 2004-2005 (Table 3 and 4). In both sites, the total dry matter ranged from 10.60-17.92 ton ha^{-1}. Low total dry matter in 2003-2004 could have resulted from late planting in both sites compared to growing season 2004-2005.

The reduction of total dry matter resulting from delaying seeding could be attributed to high temperature stress during post anthesis stage. Planting method, variety and their interaction had no significant effect on wheat total dry matter. These results could be attributed to compensation between vegetative and reproductive growth in all the treatments.

Effect of planting methods on grain water use efficiency: Grain water use efficiency values are (gWUE) shown in Table 5 and 6. The analysis of variance showed a significant difference of gWUE between sites. The mean gWUE was higher in Sidi El Aydi site than Darab. In Sidi El Aydi, gWUE ranged from 15.66-22.17 kg/ha/mm but in Darab gWUE ranged from 11.29-18.96 kg/ha/mm. In comparison to Sidi El Aydi, the lowest gWUE obtained in Darab are due to the lowest grain yield in this site. The significant interaction between planting method and variety in Sidi El Aydi revealed that the highest gWUE values were obtained with durum wheat varieties in bed planting system. This difference between species and varieties is attributed to the high grain yield in bed planting because the crop water use between varieties is not significantly different. These results suggest that durum wheat varieties Jawhar and Karim use more efficiently water in bed planting system.

CONCLUSION

This study about performance evaluation of bed planting in Moroccan conditions is the first experience for this experiment with this system in North Africa. The results obtained for two consecutive growing seasons (2003-2004 and 2004-2005) in two sites Sidi El Aydi and Darab showed interaction between planting methods and varieties. The highest grain yield in bed planting was obtained by durum varieties (Karim and Jawhar). Karim is more stable in both planting methods but Jawhar gave best grain yield in bed planting system. The availability of bed planting machines will certainly give more opportunities of research in various aspects (agronomy, soil quality, irrigation, crop health and fertilization) about this planting methods system.

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