Response of durum wheat genotypes to previous crop and N fertilization under Mediterranean conditions

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Abstract

Under Mediterranean conditions, the amount and seasonal incidence of rainfall play important roles in determining the response of wheat to carryover effects from the previous crop and to the rate of nitrogen (N) fertilization. The purpose of the present research was to evaluate the possibility of growing durum wheat in an agricultural system that is characterized by reduced inputs of fertiliser nitrogen and minimum tillage. In one growing season (1999-2000), we assessed the effects on wheat yield and grain characteristics of: (i) the previous crop (vetch and wheat), (ii) the nitrogen fertilizer level (0, 45 and 90 kg/ha $^{-1}$), and (iii) the genotype (10 were compared). Low rainfall reduced the grain yield, which ranged between 1.22 and 3.50 t/ha. The previous crop did not significantly affect the wheat grain yield, but after vetch an average 5% yield increase was observed. After wheat, the grain yield did not show any significant difference between the three N levels, while after vetch the grain yield increased significantly (+ 20.6%) with 45 kg/ha of N and remained constant with 90 kg/ha of N. On average, the cultivars Ciccio (2.40 t/ha) and Colosseo (2.28 t/ha) were the highest yielding genotypes. However, with some genotypes, significant interactions occurred with both the previous crop and nitrogen fertilization. For example, the genotype Rubiu Cixireddu showed a 45% yield increase after the vetch crop, followed by the cv Ciccio with +24%. The nitrogen fertilisation also influenced the genotypes in different ways. Yellow berry, hectolitre weight and kernel weight varied mainly with the genotypes.

Media summary

The effects of prior crop (vetch, wheat) and N fertilization on the yield and seed characteristics of several varieties of durum wheat were evaluated in southern Italy.

Key Words

Crop system, climate, grain yield, seed characteristic, genetic improvement.

Introduction

The detrimental environmental impact that conventional agriculture has produced over the years dictates the search for “sustainable” development practices that can preserve environmental resources, promote human health and ensure an adequate income to farmers. The need to protect the environment has largely influenced the agricultural policy measures taken by the European Union, which introduced the Mac Sharry reform and Agenda 2000 to progress toward the objectives of environmental quality in the primary sector. In this context, research teams that search for environmentally sound cultivation methods play a crucial role, as do the farmers who manage most of the renewable natural resources. The farmer needs access to substantial knowledge, which is not always available within farms (Dugoni, 2001).

Many studies have been conducted to examine the effects of N fertilizers and preceding leguminous and non-leguminous crop on cereal grain yield (Rowland et al. 1988; Mason and Rowland 1990; L?pez-Bellido 2001; Kumar and Goh 2002). The introduction of high-yielding wheat cultivars has increased the use of N fertilizers in the Mediterranean region. Increasing N rates does not necessarily, however, improve grain yield and quality. The benefits of grain legumes in cropping systems are well established (Giller 2001; L?pez-Bellido and L?pez-Bellido 2001; Kumar and Goh 2002). Grain legumes have a positive effect on the structure and functioning of agro-ecosystems (Caporali and Onnis 1992), and reduce the use of N fertilizers (Ofori and Stern 1987). The purpose of the present research was to evaluate the possibility of growing durum wheat in an agricultural system that could be characterised by reductions in the use of energy (fertilizer, fuel). In this experiment, the particular focus was on the effects of (i) preceding leguminous (vetch) and non-leguminous (durum wheat) crops and (ii) N-fertilizer rates, on the yield and seed characteristics of ten durum wheat genotypes under rainfed Mediterranean conditions.

Methods

The yield experiment was established in 1999-2000 at the experimental farm 'E.Pantanelli', located near Policoro, southern Italy, on a very deep clay-loam alluvial soil that was well-supplied with nitrogen, phosphorus and potassium and with no salinity problem. A split-split-plot design with 4 replicates was used, with previous crops (vetch and durum wheat) in the main plots, N fertilizer rates (0, 45 and 90 kg N/ha) in sub-plots and genotypes in sub-sub-plots of 10 m^2. The seeds were sown on November 30 in continuous rows 17 cm apart, and for each genotype the sowing rate was 400 germinated seeds per m^2. Nitrogen fertilizer was applied to wheat plots as ammonium nitrate; half was applied at sowing and half as a top dressing at the end of wheat tillering stage. Weeds were controlled between the tillering and shoot elongation stages with Tralcoxidim 22.5% + Fluroxipir 6g,Clopiralid 2.3g and MCPA 26.7g. Due to drought, a water application of 22mm was provided as supplementary irrigation on January 18. The harvest occurred on June 26.

The data of each studied parameter were analysed using the split-plot technique for ANOVA using SAS-1989 (Statistical Analyses System Inc.). Treatment means were compared using Fisher's protected least significant difference (LSD) test. LSDs for interaction comparisons were calculated using the appropriate standard error terms. In Table 1 is reported a summary of ANOVA.

Table 1. Summary of ANOVA to evaluate the effects of the treatments [1].

Source of variation	df	Grain yield	Yellow Berry[2]	Hectolitre weight	Kernel weight
Previous crop (P)	1	ns	ns	ns	ns
N rate (N)	2	*	ns	ns	ns
Inter. P x N	2	**	ns	*	*
Genotype (G)	9	**	*	**	**
Inter. G x P	9	**	ns	*	*
" G x N	18	*	ns	ns	ns
" G x P x N	18	**	ns	*	**

[1] ns, *,** = F-values non-significant and significant at $P \leq 0,05$, $P \leq 0,01$.
[2] Yellow berry refers to the proportion of white-spotted grain

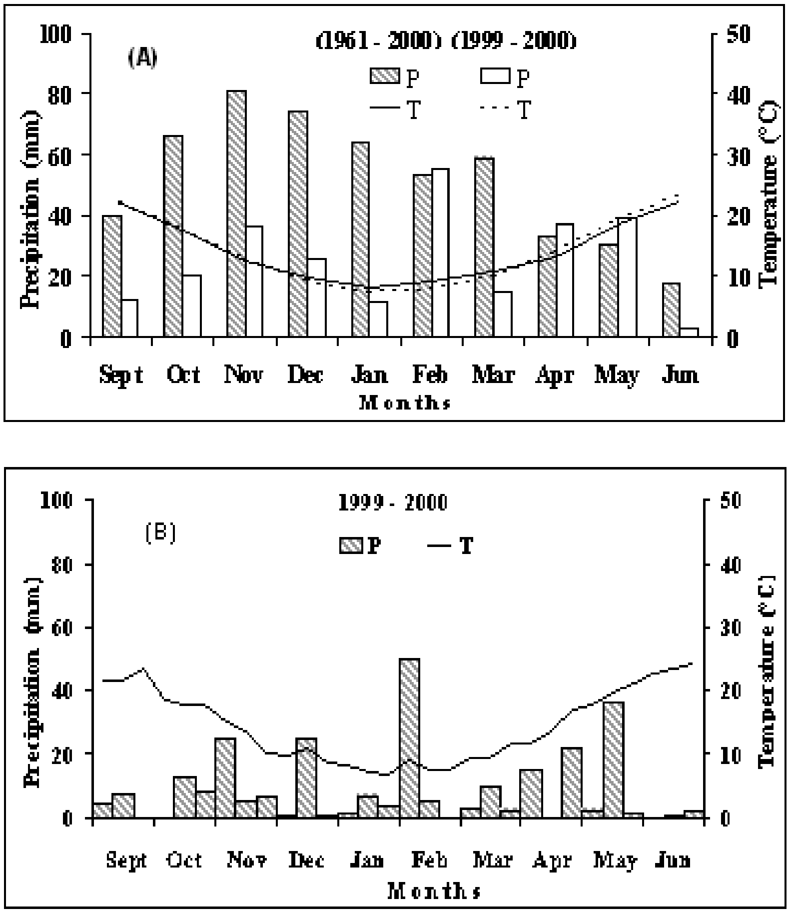

Figure 1. Monthly trends of temperature (-----) and precipitation (vertical bars) for the 40-yrs average (A), and 10-day data for the growing season 1999-2000 (B) at Policoro, Italy.

Results and discussion

Weather conditions

Figure 1 shows the weather data recorded during the growing season 1999-2000 in relation to the 40-year average. The mean temperature of the growing period did not differ from the normal one, but the rainfall, was only about half of that normally required to meet the crop water requirements. From sowing to the end of January the rainfall recorded was 37.7 mm, 100.3 mm less average, and so a water application of 22mm was provided as supplemental irrigation on January 30. Subsequently, the low rainfall recorded in March and June adversely affected wheat grain yield and quality.

Grain Yield

The grain yield averaged 2.05 t/ha, ranging between 1.22 and 3.50 t/ha for all of the 60 treatments (Table 2). The previous crop did not significantly affect the grain yield (Table 1), although in wheat after vetch an average 5% yield increase was observed (Table 2).

Table 2. Wheat grain yield (t/ha) as affected by genotype, N rate and previous crop, and seed characteristics as affected by genotype.

Genotypes	Grain yield								Grain yield	Yell. berry	Hectol. weight	1000 grain weight
	N rate (kg/ha)											
	0	45	90	mean	0	45	90	mean	(t/ha)	(%)	(kg/hL)	(g)
	after wheat				after vetch				Mean effect of genotypes [(1)]			
Mg 11/63	2.43	2.49	1.62	2.18	1.46	1.82	2.81	2.03	2.10 ab	4.1 e	73.1 d	42.3 b
Lr- AZ 2-21 P	2.22	2.04	1.83	2.03	1.80	1.67	1.77	1.75	1.89 e	5.2 c	75.7 c	39.9 c
Rubiu Cixireddu	2.16	1.47	1.56	1.73	2.54	2.46	2.55	2.52	2.12 cd	5.2 c	79.6 a	38.9 d
Trigu Cossu	1.61	1.35	1.31	1.42	1.55	1.31	1.37	1.41	1.41 f	7.2 a	70.7 e	40.4 c
Vappo	2.07	2.19	2.27	2.18	2.12	2.36	2.70	2.39	2.28 bc	4.2 e	78.1 b	37.9 e
Simeto	1.53	2.24	2.12	1.96	1.94	2.39	2.45	2.26	2.11 cd	4.2 e	76.5 c	37.9 e
Colosseo	2.75	2.88	3.50	3.04	1.65	3.08	1.76	2.16	2.60 a	4.9 cd	76.6 c	44.4 a
Rusticanu	2.27	1.94	2.03	2.08	2.30	2.75	2.18	2.41	2.24 bc	5.3 c	78.0 b	37.2 e
Ciccio	2.13	2.22	2.07	2.14	1.89	2.91	3.18	2.66	2.40 ab	4.6 de	78.6 ab	40.1 c
Locale PZ	1.35	1.26	1.22	1.28	1.22	1.46	1.41	1.36	1.32 f	6.3 b	76.0 c	41.8 b
mean	2.05	2.01	1.95	2.00	184	2.22	2.22	2.09	2.05	5.1	76.3	40.1

[(1)] Within each character means followed by the same letter are not significantly different at $P \leq 0.05$.

For grain yield, a significant interaction occurred between N fertilization and the previous crop (Table 1). The grain yield of wheat after wheat did not show any significant difference between the three N rates, whereas the yield of wheat after vetch increased significantly (+ 20.6%) with the N fertilization of 45 kg/ha or 90 kg/ha. The response to nitrogen fertilization after vetch may be a consequence of a lower impact of root pathogens on plant water relations, but the incidence of root infection was not measured. The highest yielding genotypes were, on average, the cultivars Colosseo (2.6 t/ha) and Ciccio (2.4 t/ha) followed by five genotypes (Mg 11/63, Rubiu Cixireddu, Vappo, Simeto e Rusticanu) with yields ranging from 2.28 to

2.10 t/ha. The yield of the genotypes did interact significantly with both the previous crop and with N fertilization. If confirmed, these interactions are potentially important

Grain characteristics.

The incidence of yellow berry, an undesirable trait, was low (2-10%), a consequence of the dry season. Significant differences in the proportion of yellow berry, hectolitre weight and 1000 grain weight) occurred between genotypes.

Conclusions

The results of the present research, although occurring in a single year that was characterised by a dry climatic pattern, provided some indications of the trends that may occur in an agricultural system where fertiliser inputs need to be constrained. In particular: (i) the previous leguminous crop (vetch) influenced positively the grain yield of durum wheat as compared to a non-leguminous one (wheat); (ii) only after a vetch crop was there observed a positive response in wheat grain yield to nitrogen fertilization on this fertile soil; (iii) the highest yielding genotypes were the cultivars Ciccio and Colosseo; (iv) there were significant interactions in grain yield between the genotypes and there response to the previous crop and N fertilization. These interactions, if confirmed in subsequent years, will guide farmers towards the choice of the best genotype for their particular farm and paddock fertility level.

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