TILLAGE REDUCTION IN CENTRAL EAST ITALY

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Abstract

The effect of several soil tillage methods (ploughing at a depth of 20-25 cm, chiseling at 30 cm and ploughing at 20 cm plus sub-soiling at 50 cm)) factorially combined with three biennial rotations (wheat – sugar beet; wheat-sorghum; wheat- sunflower) were studied between 2000-2005. Sugar beet confirmed the supposed higher need for deep tillage, whereas sorghum and sunflower were less sensitive. With dry soil chiseling was enough to prepare a seed bed compared to ploughing plus sub-soiling, whereas with moist soil, shallow ploughing gave the best results in sorghum but not in sugar beet. Ploughing plus sub-soiling requires more energy and it could be justified only in sugar beet. Wheat yielded better after sugar beet and sunflower than after sorghum. Minimum tillage was as efficient as shallow ploughing for wheat seed bed preparation.

Introduction

The extensive experimental activity on seed bed preparation has confirmed the use of the minimum tillage on cropping wheat in Italy, whereas in summer crops the practice is still under debate especially in function of the crop. Reduced tillage is suggested for shallow rooted crops, whereas a little deeper is recommended for deep rooted crops (sugar beet, carrot, etc.). The main tillage goal is, among others, the increase of macro porosity that allows better water infiltration, root development, nitrification, soil respiration, etc.

Wheat yield is influenced by rotation (Laureti and Pieri, 2004; Norwood, 2000; Roth *et al*., 2000) and in recent years growers have preferred to cultivate sugar beet instead of sunflower even if the yield of the cereal following it is similar.

To contribute to the knowledge of tillage and rotation effects on crop yield, an experiment was carried out in the years 2000-2005 in East Central Italy.

Materials and Methods

In an *Acquic Xerorthent, fine, mixed, calcareous, semiactive, mesic* soil were evaluated, from 2000 to 2005, three tillage methods (ploughing at a depth of 20-25 cm, chiseling at 30 cm and ploughing at 20 cm plus sub-soiling at 50 cm). They were factorially combined with three biennial rotations (wheat – sugar beet; wheat-sorghum; wheat- sunflower) replicated four times. Tillage for wheat consisted of ploughing at 25 cm for all years and minimum tillage the last three years

Crops were established in the winter of 2000 in chiselled soil and the first differential tillage started in the summer of the same year. The results of the last five years are reported where there was a tillage effect.

Weather conditions

In the five years reported, rainfall and temperature were very different (Figure 1). Rainfall in April and June (of wheat interest) was nearly always below the average, and in June-August (of summer crop and tillage interest) it was often below the average, reaching the lowest values in the 2003 when the highest deficit occurred. Rainfall significantly influenced crop results, directly and throughout the effects on tillage.

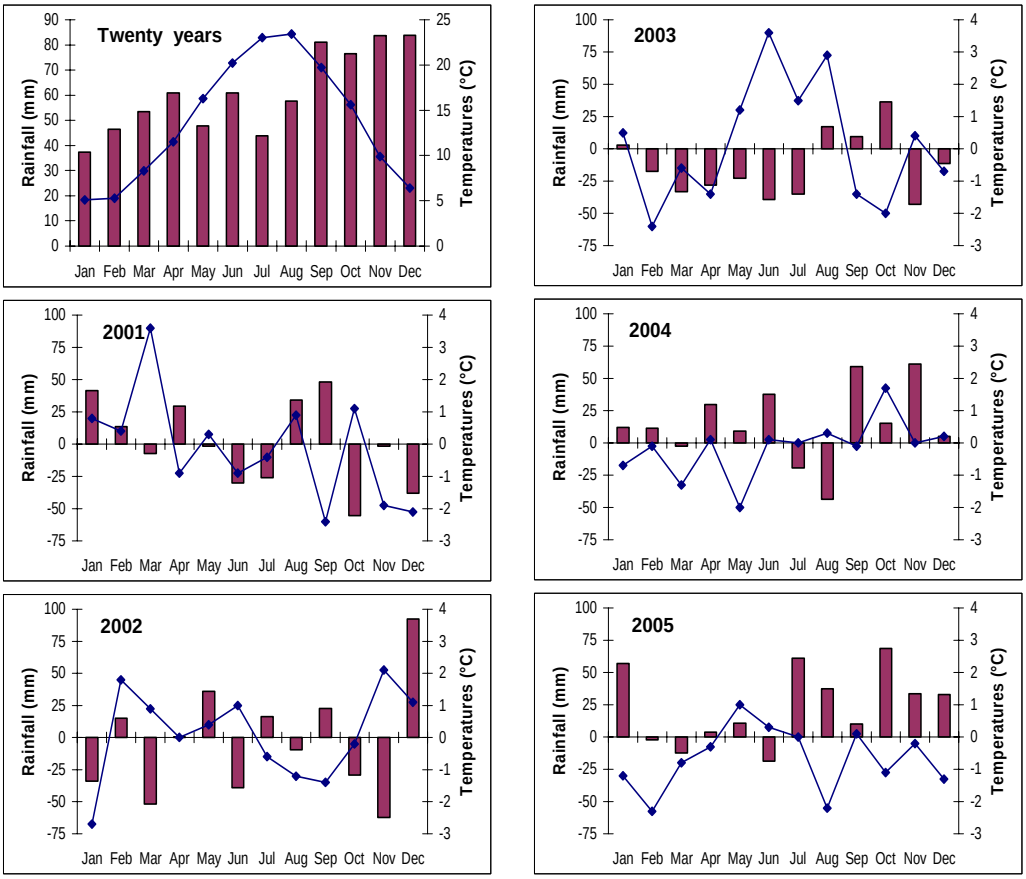

Figure 1. Rainfall (mm) and mean temperatures (°C) of the experimental years compared with the previous twenty-year period.

Temperatures were similar to the 20 year average, with values higher or lower according to low o no rainfall.

Year's effects

This factor was significant for all traits recorded, confirming that results are significantly influenced by rainfall during the year of cropping and during the year of tillage. Year's effects were reported when combined with the other factors evaluated.

Tillage effects on summer crops Sugar beet

Tillage resulted in significant differences in root yield only in 2002 (table 1) when ploughing plus sub soiling showed better values than shallow ploughing but not better than chiseling. Larger roots had lower sugar content so no difference in sugar yield was found in 2002.

Table 1 Tilling effects on sugar beet combined with the years*

Years	Root yield (t ha^{-1})			Sugar content (°S)		
	Chiseling	Ploug + subsoil	Ploughing	Chiseling	Ploug + subsoil	Ploughing
2001	27,63 d	30,92 cd	28,16 cd	12,2 fg	12,0 fg	11,6 fg
2002	49,33 ab	50,45 a	44,21 b	12,2 fg	11,4 g	12,7 f
2003	21,00 e	21,21 e	19,00 e	17,0 cd	18,5 ab	17,6 bc
2004	29,83 cd	30,08 cd	29,29 cd	19,1 a	19,6 a	17,0 cd
2005	31,25 cd	34,25 c	30,15 cd	15,3 e	15,8 de	15,5 e
Mean	31,81	33,38	30,16	15,2	15,4	14,9
LSD<0,05	6,2			1,3		

*In all the table means with the same letter are not significant differently at P<0,05 according to test "t"

On the average for all years, sugar yield was, in better with ploughing plus sub-soiling, without significant differences from chiseling which did not differ from shallow ploughing (Table 2).

Table 2 Tilling effects on sugar yield

Tillage	Sugar yield	
	teoric	white
	(t ha^{-1})	
Chiseling	4,68 ab	3,74 ab
Ploughing + subsoil	4,93 a	3,92 a
Ploughing	4,37 b	3,39 b
Mean	4,66	3,68
LSD<0,05	0,40	0,37

The difference of 0.5 t ha^{-1} of sugar justifies the higher tillage cost. Chiseling gave intermediate results and was interesting for the lower cost and time required. Tillage influenced the amount of amino nitrogen in the juce, but only in the 2004 sugar on the molasses was higher in shallow ploughing, may be for lower water availability (table 3).

Sorghum

Chiseling gave the best yield in 2002 and the worst in 2003. This was probably related to the soil moisture at the time of tillage and water availability in the cropping year. In 2002, with the best yield (Table 4), tillage was done in 2001 with a very dry soil, because it is done after two months without rainfall, and during the cycle, after blooming, the crop had 60 mm of rainfall that allowed good grain filling, but negatively influenced chiseling for the following year.

Table 3 Qualitative traits of sugar beet in the combination of tillage and years

Years	Amino nitrogen (meq % g °S)			K	Na	Alcalin.	Purity
	Chise-ling	Ploug+ subsoil	Plou-ghing	(meq % g °S)		(%)	
2001	21,9 ij	27,4 gi	27,9 fh	39,2 b	18,3 b	2,3 A	87,5 b
2002	41,7 ab	46,4 a	37,4 bd	51,7 a	23,5 a	1,8 B	82,7 c
2003	29,8 eg	33,2 df	34,8 ce	37,7 bc	13,8 c	1,7 B	87,4 b
2004	25,8 g	25,9 gj	40,1 bc	23,5 d	10,3 c	1,1 C	90,2 a
2005	21,5 j	24,6 gj	23,4 hj	32,4 c	11,1 c	1,9 B	89,9 a
Mean	28,1	31,5	32,7	36,9	15,4	1,8	87,5
LSD< 0,05	5,6			5,4	3,5	0,3	1,3

The 60 mm rainfall totally refilled the water holding capacity of the soil, but, even if tillage was done after ten days, the water in the soil reduced the chisel and sub-soiling action resulting in greater compactness in the deeper layers, which were probably too wet.

A partial similar effect was also present in ploughing plus sub-soiling where the sub-soiler had an action similar to a chisel in the soil.

Sunflower

The crop was less sensitive than the others to tillage and weather conditions. Yield was not influenced by tillage and in the worse year yield reduced (Table 5) only 20% of the overall mean and 30% less than the best value.

Table 5 Yield and its components in sunflower

Years	Yeld	Plant height	Head diameter	Stand	Thousand-seed w
	($q\ ha^{-1}$)	(cm)		($n\ m^{-2}$)	(g)
2001	25,9 a	142 c	18,8 b	4,6 c	52,6 B
2002	27,4 a	157 b	22,6 a	5,1 b	61,7 A
2003	19,9 b	152 b	15,8 d	3,9 d	49,6 B
2004	27,9 a	165 a	17,1 c	5,1 b	62,0 A
2005	28,9 a	139 c	19,6 b	5,8 a	50,5 B
Mean	26,0	151	18,8	4,9	55,3

Residual effect of summer crops tillage

In the average of five years wheat yielded less after sorghum (4.57 tha^{-1}) than after sunflower (4.78 tha^{-1}) or sugar beet (4.78 t ha^{-1}) with a difference of 4.4%. The lower wheat yield after sorghum could be related to the rate of nitrogen applied, 150 kg ha^{-1}, chosen on the basis of the rule of regional low environmental impact. The nitrogen fertiliser applied was not enough for wheat and for bacterial needed to decompose the sorghum residue. The residual effect of summer crops tillage was not significant neither alone nor combined with tillage for wheat. The 5 year average, for wheat, yield was, in fact, 5.0 t ha^{-1} after chiseling, 5.2 t ha^{-1} after ploughing plus sub soiling, and 5.10 t ha^{-1}after shallow ploughing.

Tillage for wheat

Shallow ploughing or minimum tillage with a cultivator, before planting wheat with a planter combined with a rotary hoe, after the three summer crops, did not give differences in the cereal yield (5.12 vs. 5.13 t ha^{-1} respectively, for ploughing and cultivator) confirming that minimum tillage is enough for the crop.

Conclusion

The experiment confirmed the supposed higher need of sugar beet for deep tillage, whereas sorghum and sunflower were less sensitive. With dry soil chiseling was enough to prepare a seed bed compared to ploughing plus sub-soiling, whereas with moist soil, shallow ploughing gave the best results in sorghum but not in sugar beet. Sorghum, even if in only one year, was more sensitive than sugar beet to tillage.

Wheat yielded better after sugar beet and sunflower than after sorghum, which is contrary to that reported by Norwood (2000) who found better values after sorghum and corn than after sunflower. Lower wheat yield after sorghum could also be related to the amount of fertiliser applied (150 kg ha^{-1}) which was not enough for the crop and decomposition of sorghum residue.

Ploughing plus sub-soiling requires more energy and it could be justified only in sugar beet. Minimum tillage was as efficient as shallow ploughing for wheat seed bed preparation.

Acknowledgments.
The Authors thank Mauro Tiberi for soil classification and Mangoni Lorella for help in recording data

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