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ABSTRACT

We have analyzed soft white (SW) and hard red (HR) wheat grain produced in organic, no-till, and conventional cropping systems for grain characteristics, ash, protein, total phenolic content, antioxidant capacity and baking quality. SW wheat grain produced with no-tillage exhibited significantly greater kernel diameter and weight than the grain of tilled SW. No-till management practices lowered protein content and antioxidant capacity, whereas it imparted no significant effects on quality of cake and pan bread. Organically-produced SW wheat grain was higher in test weight, kernel diameter and kernel weight than grain produced in conventional cropping systems. Organic management practices appeared to produce harder kernels of HR wheat than conventional one but did not affect kernel weight and size. Compared to conventional wheat grain, organic SW wheat grain was lower in flour protein content by 2.19% under low fertility management but was 0.8% higher under high fertility management. There was no significant effect of organic management practices on sponge cake volume and bread loaf volume.

INTRODUCTION

There is growing consumer demand for organic and no-till wheat, due to their perception as being safe, healthy and sustainable. Considering the known effects of environmental conditions on grain yield and quality, we hypothesized that wheat grain characteristics would vary among different cropping systems.

MATERIALS & METHODS

Wheat grain

- Produced with or without tillage
 - Soft white (SW) winter wheat : 'ORCF102', three field replications at Oregon State University, CBARC, Pendleton, OR.
 - Hard red (HR) spring wheat : 'Vida', three field replications at Montana State University, Bozeman, MT
- Produced in organic or non-organic (conventional) cropping systems
 - SW winter wheat : "Brundage96", three field replications at Washington State University, Pullman, WA
 - HR spring wheat : "Vida", three field replications at Montana State University, Bozeman, MT

Characterization of wheat grain and flour

- Kernel physical properties
 - Test weight, SKCS (kernel hardness, weight, and diameter)
- Antioxidant properties of whole wheat
 - Total phenolic content by Folin-Ciocalteu reagent,
 - ABTS radical scavenging capacity
- Composition of wheat flour
 - Protein and ash content
- Baking quality evaluation
 - SW wheat: sponge cake volume, HR wheat: loaf volume of bread

RESULTS AND DISCUSSION

Table 1. Total phenolic content and antioxidant capacity of wheat grain produced with or without tillage**

Wheat Class	Tillage	Total Phenolic Content (mg Gallic acid Eq./g)	Total Antioxidant Capacity, TEAC, (mmol Trolox/g)
Soft White	No-Tilled	4.07 ^b	22.64 ^b
	Tilled	4.20 ^a	24.87 ^a
Hard Red	No-Tilled	4.77 ^a	28.97 ^a
	Tilled	4.75 ^a	28.46 ^a

*Values are averages of three field replication.

**Values with different letters within each wheat class are significantly different ($P < 0.05$).

SW wheat grain produced with no-tillage exhibited lower total phenolic content and total antioxidant capacity than that produced with tillage. This result is partly explained by their differences in kernel size and weight.

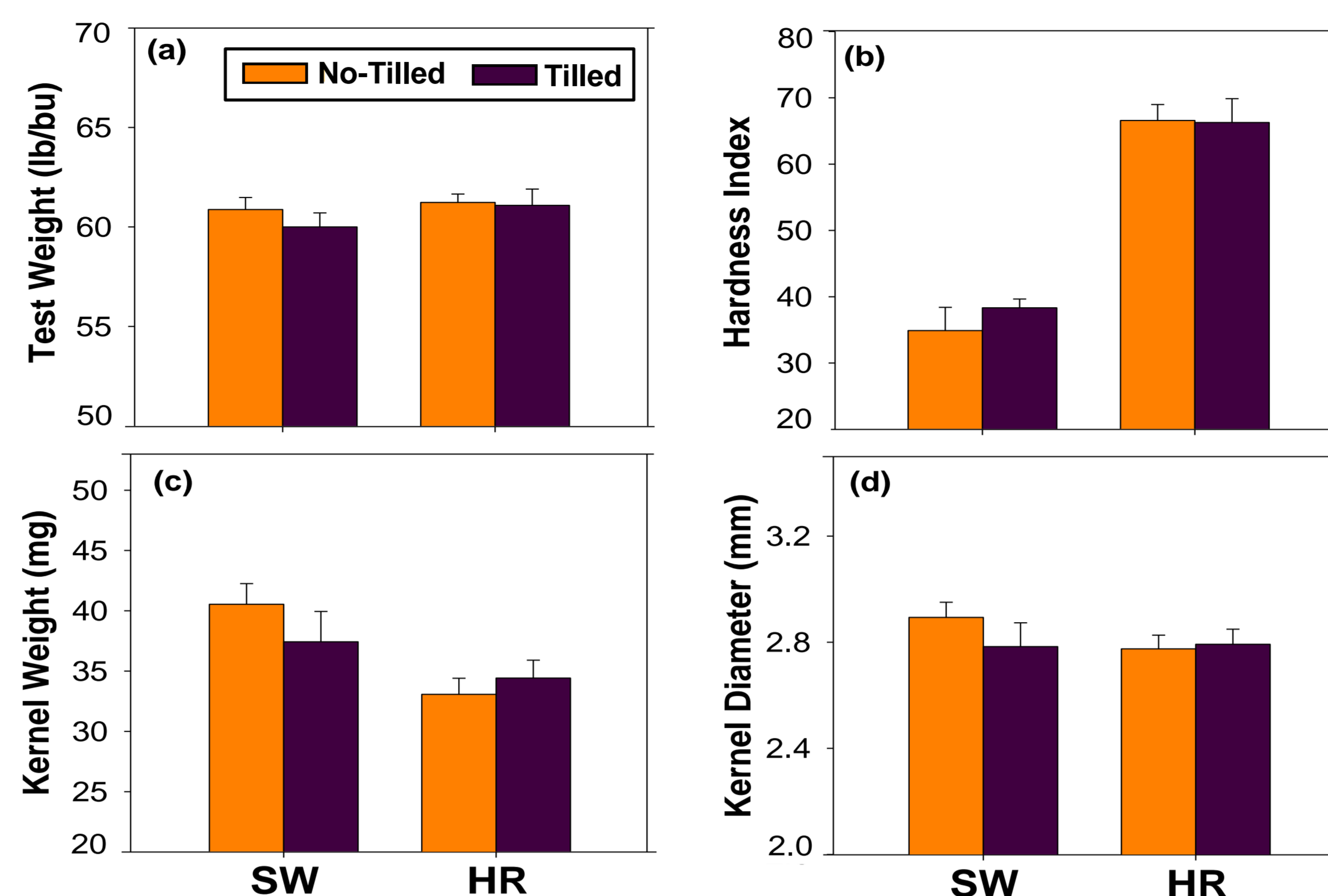


Figure 1. Physical characteristics of wheat grain produced with or without tillage. No-tilled management practices produced SW wheat grain of higher test weight, kernel weight and kernel diameter than tilled one did, whereas no significant differences between no-till and tillage in grain characteristics were observed in HR wheat.

Table 2. Composition and baking quality of wheat grain produced with or without tillage**

Class	Tillage	Protein (%)	Ash (%)	Cake Volume (ml)	Bread Loaf Volume (ml)
Soft White	No-Tilled	6.19 ^b	0.38 ^a	1231 ^a	-
	Tilled	7.53 ^a	0.40 ^a	1220 ^a	-
Hard Red	No-Tilled	10.58 ^a	0.37 ^a	-	939 ^a
	Tilled	10.49 ^a	0.38 ^a	-	965 ^a

*Values are averages of three field replication.

**Values with different letters within each wheat class are significantly different ($P < 0.05$).

Flour protein was lower in SW wheat grain under no-till than under conventional tillage. However, no differences in ash content and sponge cake volume were observed between tillage treatments. Tillage treatments caused no significant effects on protein and ash content of flour or bread loaf volume in HR wheat.

Table 3. Total phenolic content and antioxidant capacity of wheat grain produced in organic or conventional management practices

Class	Cultivation	Fertility	Total phenolic content (mg Gallic acid Eq./g)	Total antioxidant capacity, TEAC, (mmol Trolox/g)
Soft White	Organic	Low	4.23 ^b	22.99 ^b
		High	4.67 ^a	27.55 ^a
	Conventional	-	4.58 ^a	27.20 ^a
Hard Red	Organic	Low	4.84 ^a	28.34 ^a
		High	4.72 ^a	29.49 ^a
	Conventional	Low	4.65 ^a	27.09 ^a
		High	4.77 ^a	29.84 ^a

*Values are averages of three field replication.

**Values with different letters within each wheat class are significantly different ($P < 0.05$).

Organic SW wheat grain produced under low fertility management exhibited lower total phenolics content and antioxidant capacity than organic grain under high fertility management or conventional grain. This result may be partly caused by comparatively larger kernel size of organic SW wheat of low fertility (Fig. 3c & d). No differences in both total phenolic content and antioxidant capacity were observed between organic and conventional wheat.

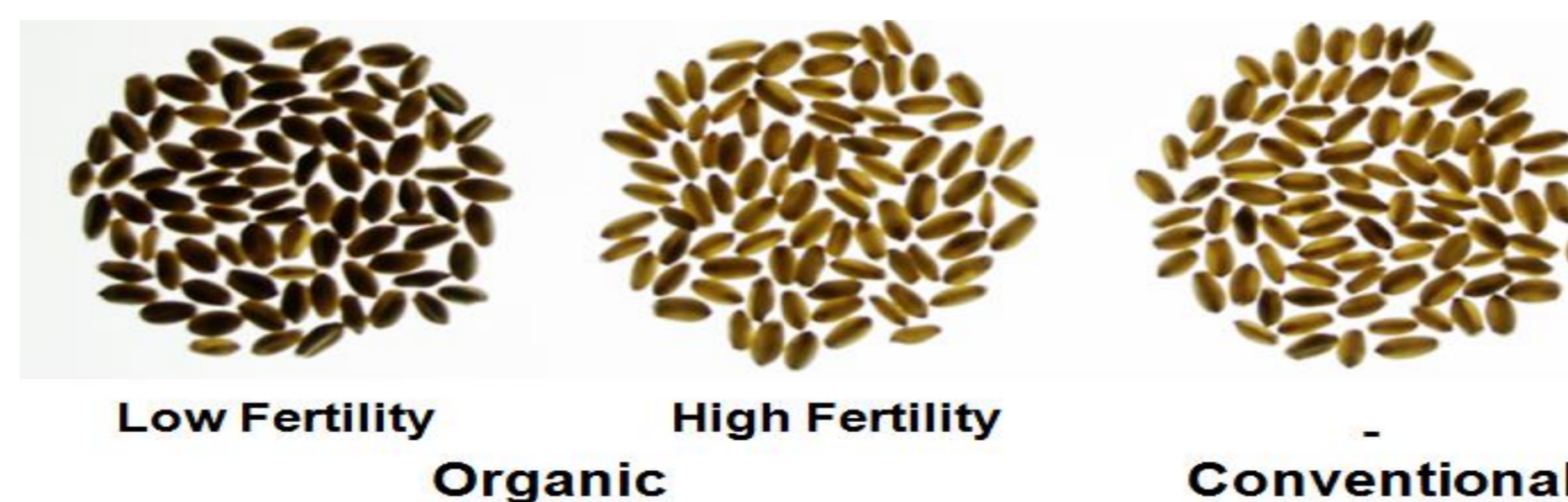


Figure 2. Vitreosity of soft white wheat grain produced in organic and conventional cropping systems.

Low fertility organic management practices (left) produced opaque (non-vitreous) grain of SW wheat, while grain produced under high fertility organic or conventional management practices was translucent (vitreous).

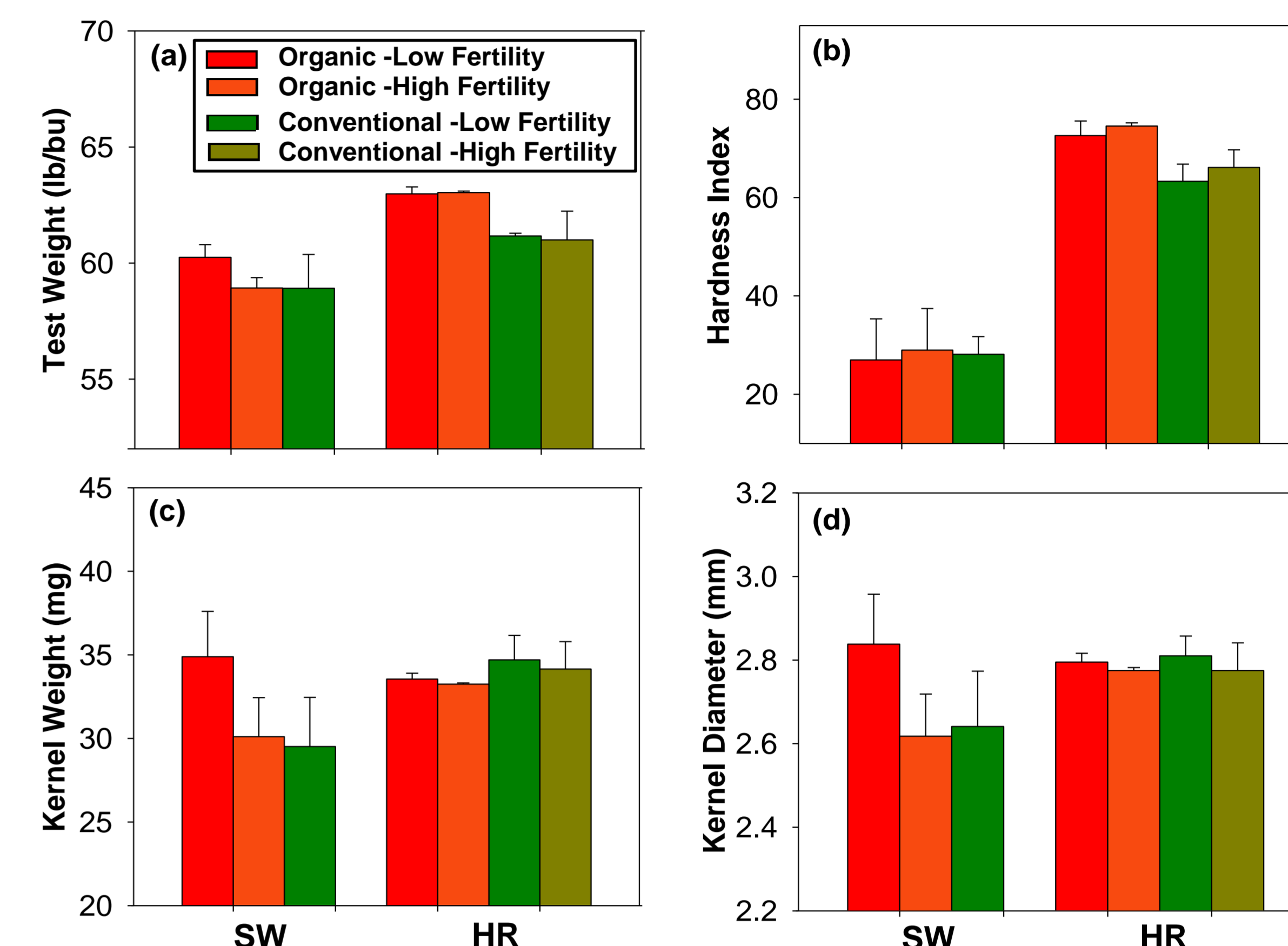


Figure 3. Physical characteristics of wheat grain produced in organic or conventional management practices.

Organic SW wheat produced under low fertility management showed significantly higher test weight, kernel weight and diameter than those produced under high fertility or in conventional management practices. Organic HR wheat grain exhibited higher test weight and kernel hardness than conventional wheat grain.

Table 4. Composition and baking quality of wheat grain produced in organic or and conventional management practices

Class	Cultivation	Fertility	Protein (%)	Ash (%)	Cake Volume (ml)	Bread Loaf Volume (ml)
Soft White	Organic	Low	6.24 ^b	0.42 ^{ab}	1217 ^a	-
		High	9.27 ^a	0.44 ^a	1132 ^a	-
	Conventional	-	8.43 ^a	0.40 ^b	1195 ^a	-
Hard Red	Organic	Low	9.90 ^{bc}	0.35 ^a	-	884 ^b
		High	10.78 ^{ab}	0.36 ^a	-	944 ^{ab}
	Conventional	Low	9.05 ^c	0.39 ^a	-	899 ^b
		High	11.93 ^a	0.36 ^a	-	1032 ^a

*Values are averages of three field replication.

**Values with different letters within each wheat class are significantly different ($P < 0.05$).

Protein content of wheat grain was significantly affected by fertility but little by organic vs. conventional management practices. Organic SW wheat grain produced under high fertility management showed higher protein content than that of conventional wheat. There were no consistent effects of organic management practices on sponge cake volume and loaf volume of bread, whereas the effects of fertility were evident.

CONCLUSIONS

- Both no-tilled and organic management practices produced softer, heavier and larger grain of SW wheat, and harder grain of HR wheat than conventional practices.
- Total phenolic content and antioxidant capacity of wheat grain were reduced by no-tilled and organic management practices, partly due to increases in kernel size and weight.
- Protein content of wheat grain was significantly affected by fertility but not organic vs. conventional practices.
- No-tilled and organic management practices had no significant effects on sponge cake volume from SW wheat and bread loaf volume from HR wheat.

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