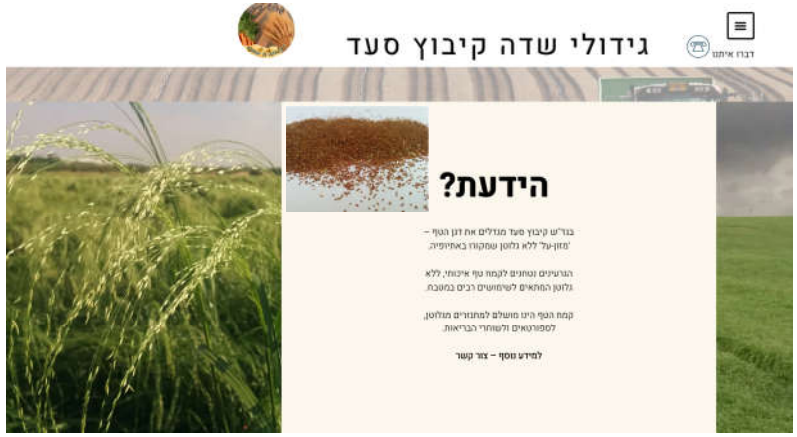
Effect of Plant Nutrition on the Nutritional Value of teff grown in Israel

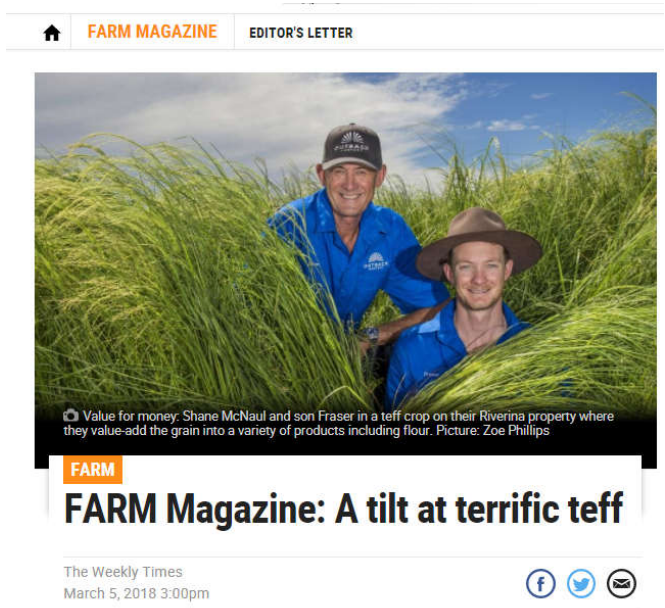
Zipora Tietel

Greidinger Conference, March 2019

Increasing Worldwide Interest in Teff



Source: Gadash-Saad website



Teff Nutritional Benefits

- Rich in minerals (Zn, Ca, P) and vitamins (vit. A, C)
- High iron
- High protein (10.4%)
- Low fat (2.3%)
- High fiber (7.3%)

- All amino acids (including 9 essential)
- Essential fatty acids (oleic and linoleic)
- Gluten free
- Low glycemic index

Teff Research

Worldwide interest and consumption of teff is growing steadily.

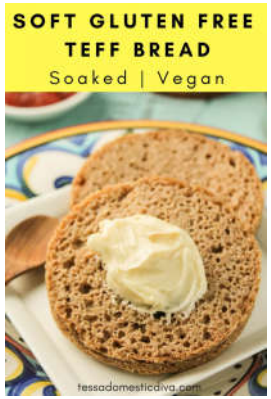
The main incentive is its outstanding nutritional quality and its health-promoting properties

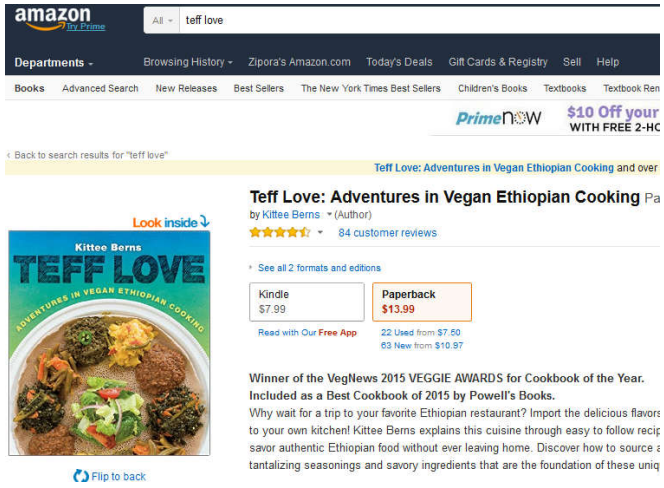
Today's consumers are much aware of their food's health benefits, and choose accordingly.

Teff's consumers are celiac and diabetic patients, constantly looking for alternatives.

Information regarding teff is very limited.

Teff Products





Israeli Teff Products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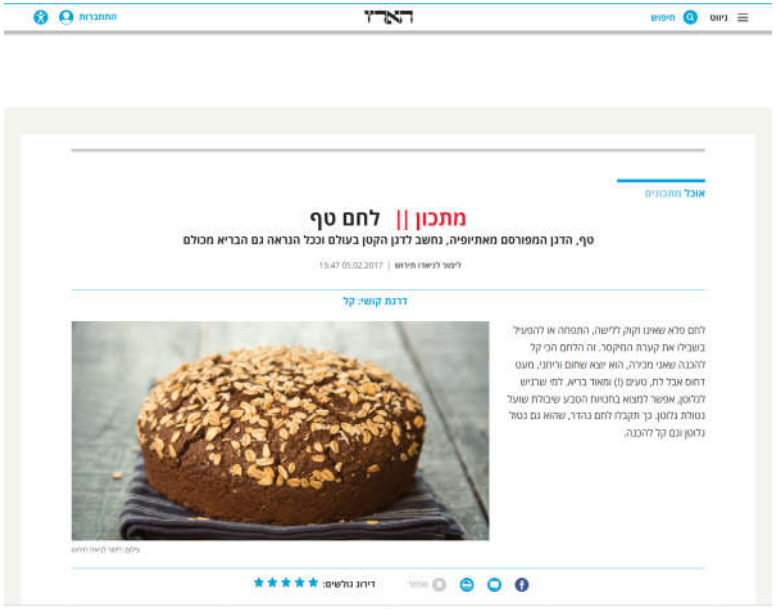
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דרגת קושי: קל
לחם פלא שאינו תקוק ללישה, התפיחה או להפעיל בשבילו את קערת המיקסר. זה הלחם הכי קל להכנה שאני מכירה, הוא יוצא שלום וריחני, מעט דחוס אבל לח, טעים (!) ומאוד בריא. למי שרגיש לגלוטן, אפשר למצוא בחנויות הסבע שיבולת שועל נטולת גלוטן. כך תקבלו לחם בהדר, שהוא גם נטול גלוטן וגם קל להכנה.
דירוג גולשים:


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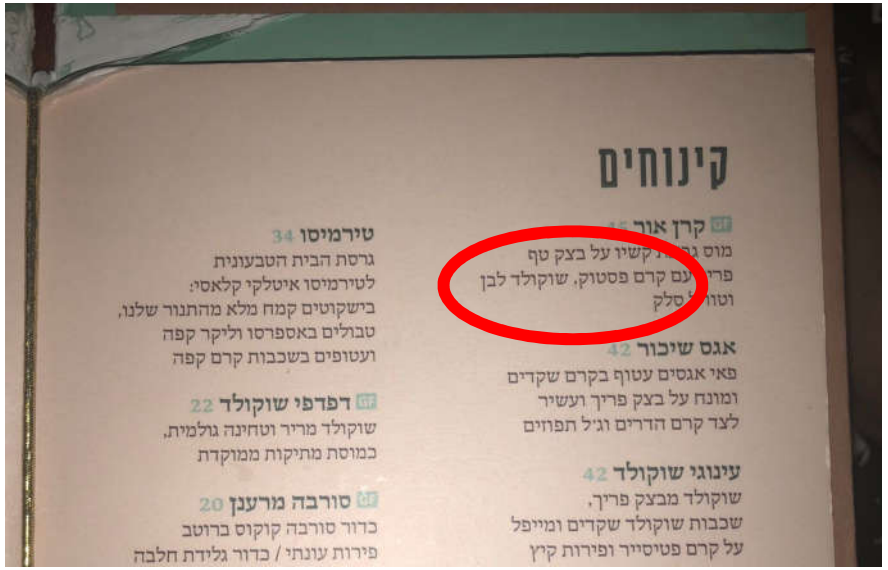
TEFFMAN
100% קמח טף
הכי בריא שיש


קינוחים
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עם קרם פסטוק, שוקולד לבן
וטו סלק
אגס שיכור 42
פאי אגסים עטוף בקרם שקדים
ומונח על בצק פריך ועשיר
לצד קרם הדרים וג'ל תפוזים
עינוגי שוקולד 42
שוקולד מבצק פריך,
שכבות שוקולד שקדים ומייפל
על קרם פטיסייר ופירות קיץ
טירמיסו 34
גרסת הבית הטבעונית
לטירמיסו איטלקי קלאסי:
בישקוטים קמח מלא מהתנור שלנו,
טבולים באספרסו וליקר קפה
ועטופים בשכבות קרם קפה
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סורבה מרענן 20
כדור סורבה קוקוס ברוטב
פירות עונתי / כדור גלידת חלבה

Research Aims

1. Study the effect of teff plant fertilization on the composition of teff phytochemicals.

2. To profile the content and composition of phytochemicals in different teff varieties.

3. To study the effect of cultivation area on teff nutritional composition.

Research Methods-Quality parameters

1. Total phenol and flavonoid contents- spectrophotometric methods.

2. Phenolic acid composition- HPLC-DAD method.

3. Fatty acid composition- GC-MS.

4. Biochemical activity- antioxidative capacity- ABTS methods.

5. Mineral contents- Zn, Fe, Ca, Mg, Cu, Mn- Atomic absorption.

Fertilization effect on teff nutritional value

	T1	T2	T3	T4	T5	T6	T7	T8	T9
N (ppm)	0	30	60	120	60	60	60	60	60
P (ppm)	6	6	6	6	0	3	12	6	6
K (ppm)	40	40	40	40	40	40	40	0	80

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
N (ppm)	10	20	80	120	40	40	40	40	40	40	40
P (ppm)	6	6	6	6	1	3	12	6	6	6	6
K (ppm)	40	40	40	40	40	40	40	10	20	80	40

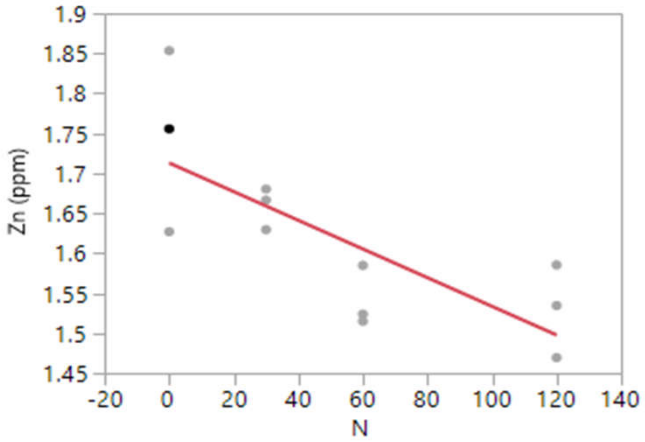
Teff mineral contents

Table 1 The proximate (db[1]) and microelement compositions of teff grain compared with some gluten containing and gluten free cereals

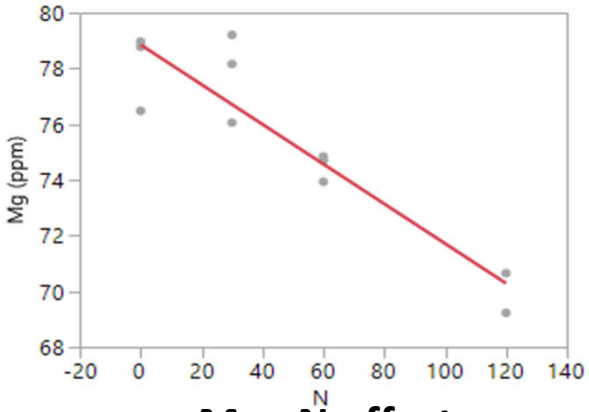
	Component	Gluten rich cereals			Gluten-free cereals				
		Barley	Wheat	Rye	Teff	Maize	Brown rice	Sorghum	Pearl millet
√	Calcium (mg/100 g)	$34^{‡}$	$39.45^{¥}$	31.5^{α}	$165.2^{\dagger}$	48.3^{β}	6.85^{λ}	50^{θ}	46^{σ}
√	Copper (mg/100 g)	$0.52^{‡}$	$0.23^{a\ ¥}$		$2.6^{\dagger}$	1.3^{β}	0.16^{λ}	0.41^{μ}	1.06^{σ}
√	Iron (mg/100 g)	$2.43^{‡}$	3.5^{δ}	2.7^{α}	$15.7^{\dagger}$	4.8^{β}	0.57^{λ}	6^{θ}	
√	Magnesium (mg/100 g)	$94.3^{‡}$	$103.5^{a\ ¥}$	92^{α}	181.0^{θ}	107.9^{β}	16.88^{λ}	180.0^{θ}	137^{σ}
√	Manganese (mg/100 g)	$8.97^{‡}$	$0.95^{¥}$		$3.8^{\dagger}$	1.0^{β}	0.36^{λ}		
√	Phosphorus (mg/100 g)	563^{φ}	–	359^{α}	$425.4^{\dagger}$	299.6^{β}	61.7^{λ}	263.3^{μ}	379^{σ}
	Potassium (mg/100 g)	507^{φ}	–	412^{α}	$380.0^{\dagger}$	324.8^{β}	181.71^{λ}	225.23^{μ}	
	Sodium (mg/100 g)	25.4^{φ}	–		$15.9^{\dagger}$	59.2^{β}	0.54^{λ}	6.18^{μ}	
√	Zinc (mg/100 g)	$2.2^{c\ ‡}$	$1.94^{¥}$	3.0^{γ}	$4.8^{\dagger}$	4.6^{β}	2.0^{γ}	2.0^{γ}	3.1^{σ}

Gebremariam et al., 2014. DOI 10.1007/s13197-012-0745-5

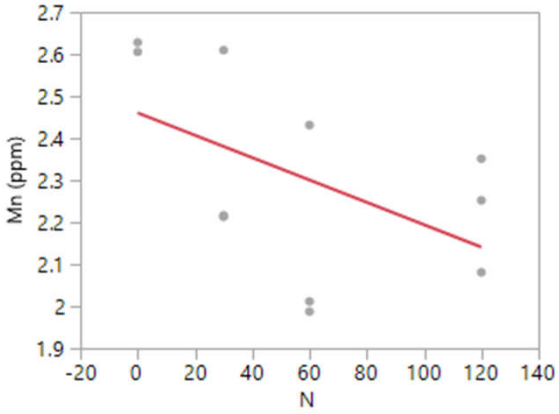
N Fertilization effect on teff minerals



Zn –N effect
R^2=0.579; P≤0.0041



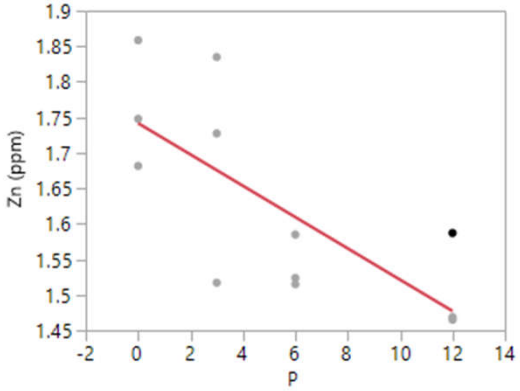
Mg –N effect
R^2=0.855; P≤0.0001



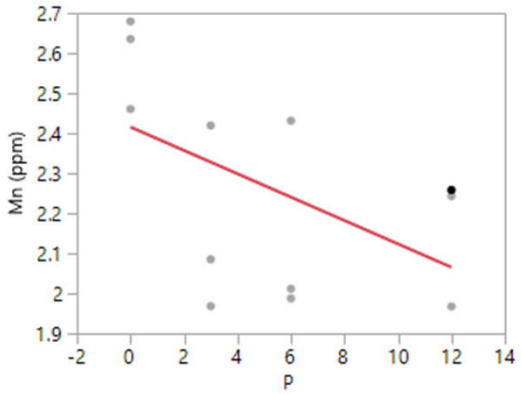
Mn –N effect
R^2=0.260; P≤0.109

- **Increasing N fertilization resulted in a decrease in seed Zn and Mg in the both varieties.**

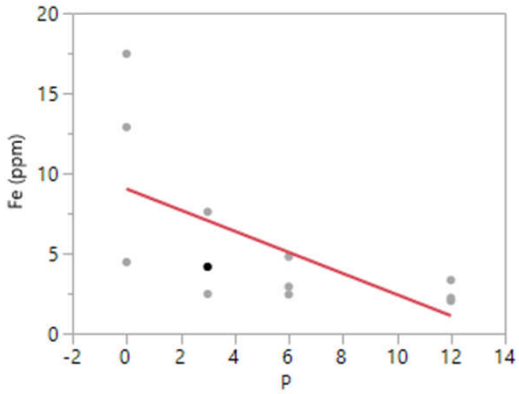
P Fertilization effect on red teff minerals



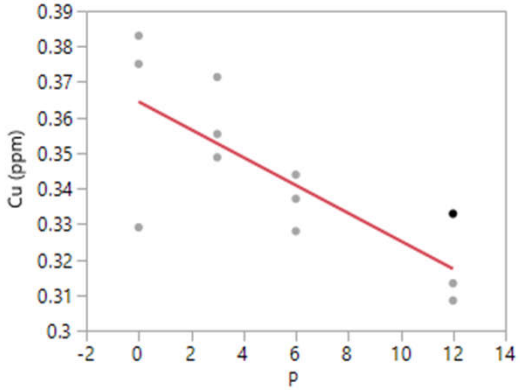
Zn –P effect
R^2=0.535; P≤0.007



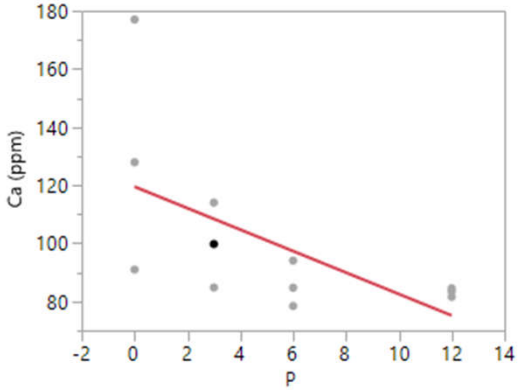
Mn –P effect
R^2=0.269; P≤0.084



Fe –P effect
R^2=0.399; P≤0.028



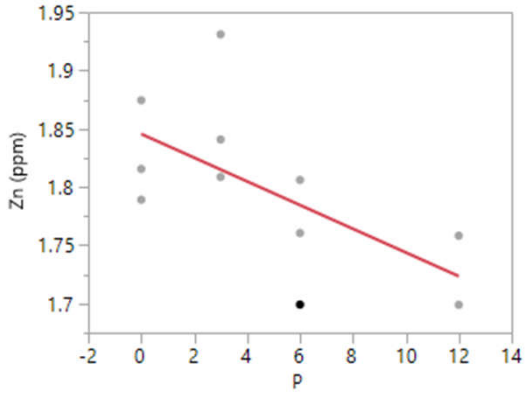
Cu –P effect
R^2=0.581; P≤0.004



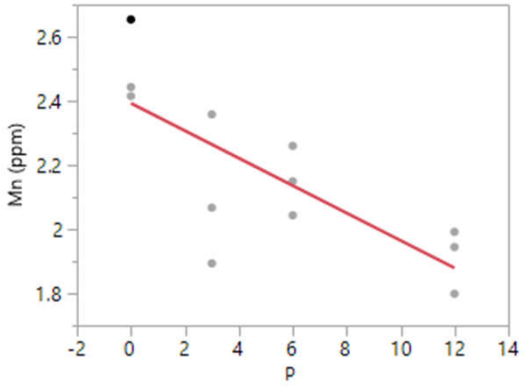
Ca –P effect
R^2=0.366; P≤0.037

- **Increasing P fertilization resulted in a decrease in seed Zn, Fe, Cu and Ca in the both varieties.**

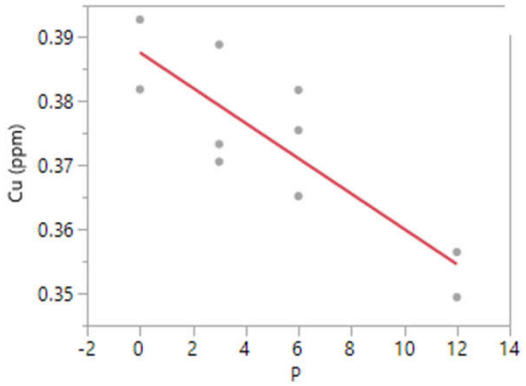
P Fertilization effect on white teff minerals



Zn white –P effect
R^2=0.398; P≤0.037



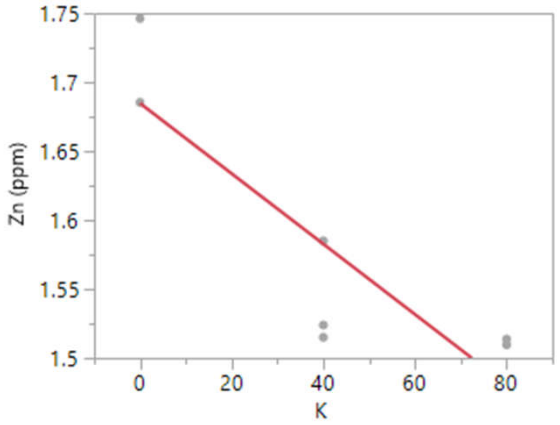
Mn white –P effect
R^2=0.587; P≤0.004



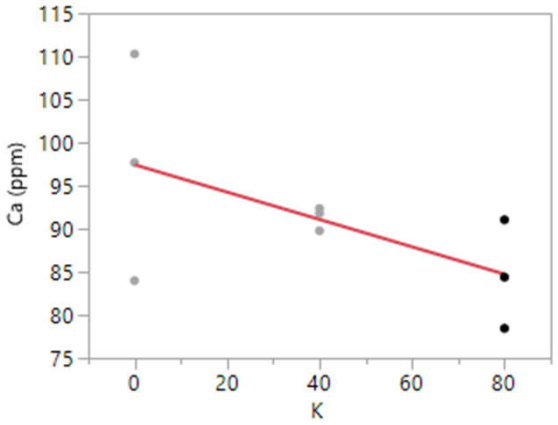
Cu white –P effect
R^2=0.728; P≤0.002

- **Increasing P fertilization resulted in a decrease in seed Zn, Mn and Cu in the white variety.**

K Fertilization effect on red teff minerals



Zn red- K effect
R^2=0.752; P≤0.011



Ca red- K effect
R^2=0.360; P≤0.087

- **Increasing K fertilization resulted in a decrease in seed Zn and Ca, only in the red variety.**

Fertilization effect on mineral contents in teff

- Generally, high fertilization levels negatively affected mineral contents of teff (in the field experiment).
- Zinc was the most sensitive to fertilization.
- Red variety was more sensitive to fertilization than white.
- Phosphorus had the highest effect on seeds.

	Ca		Mg		Fe		Zn		Cu		Mn	
	W	R	W	R	W	R	W	R	W	R	W	R
N			-	-			-	-			-	-
P	-	-			-	-	-	-	-	-	-	-
K		-						-				

Fertilization effects- nutritional aspects

- Increasing N,P and K fertilization resulted in lower Zn contents, mainly in the red cultivar.

- Increasing nitrogen and phosphorus fertilization resulted in lower Mn levels, in both cultivars.

- Zinc and manganese are highly important in vegetarian nutrition.

Teff polyphenol contents

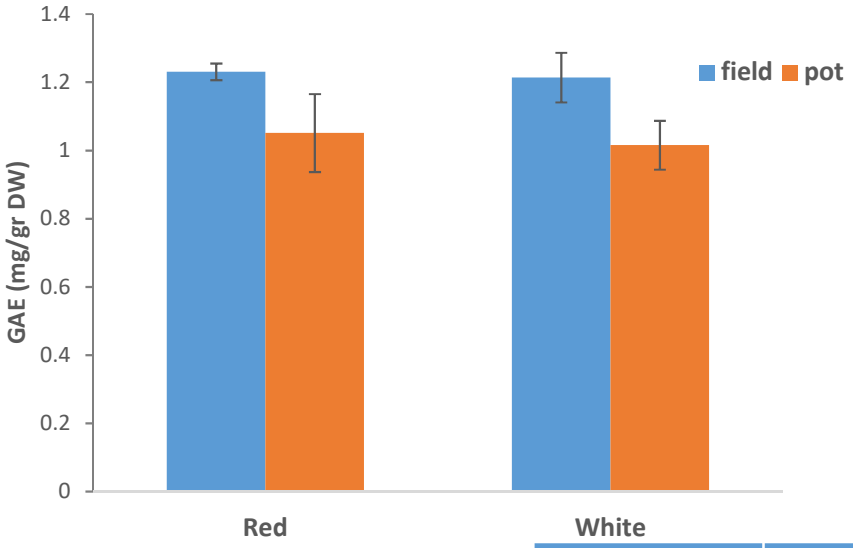


Table 1
Total flavonoid (TFC) and phenolic (TPC) content in teff.

Sample	Total TFC (mg RE/g)	Total TPC (mg GAE/g)
Teff flour (Bolivia)	1.00 ± 0.03^{a}	1.77 ± 0.03^{a}
Brown teff (Bolivia)	1.06 ± 0.03^{a}	1.86 ± 0.03^{b}
White teff (Bolivia)	0.62 ± 0.02^{b}	1.42 ± 0.02^{c}
Brown teff (USA)	1.16 ± 0.03^{c}	2.19 ± 0.02^{d}
White teff (USA)	0.67 ± 0.02^{b}	1.41 ± 0.02^{c}

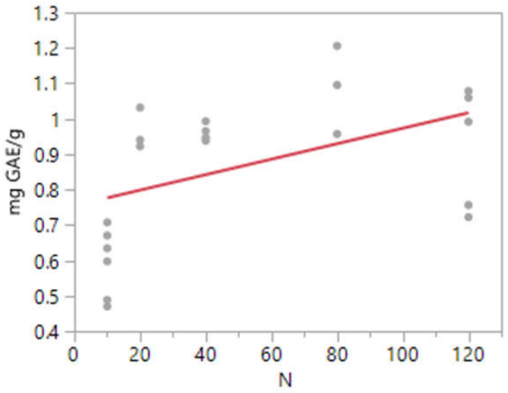
Kotaskova et al., 2016, DOI:10.1016/j.jfca.2015.11.001

	Total flavonoids (mg GAE/gr DW)	Total Polyphenols (mg/ gr DW)
Buckwheat	0.91	1.46
Oat	0.22	1.05
Quinoa	0.65	1.02
Rice	0.33	0.38
Wheat	0.53	N.D
Amaranth	0.21	N.D

Gorinstein et al., 2007, DOI 10.1007/s00217-006-0417-7

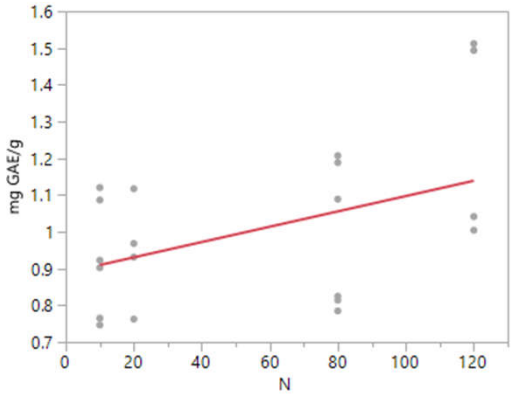
N Fertilization effect on polyphenol contents-Pot

White



R^2=0.245; P≤0.014

Red

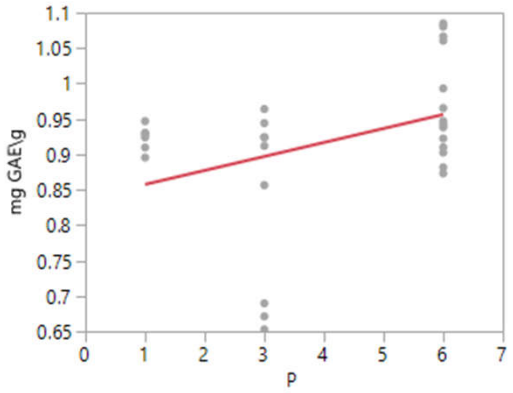


R^2=0.21; P≤0.025

- Increasing nitrogen caused an increase in seed polyphenol contents.
- Similar response for both cultivars.
- Wheat was reported to show the same trend of increasing polyphenols with increasing nitrogen.

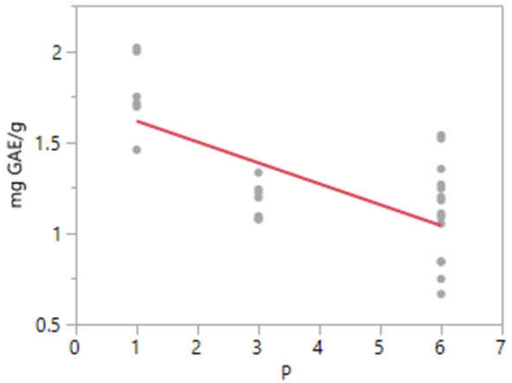
P Fertilization effect on polyphenol contents-Pot

White



R^2=0.133; P≤0.039

Red

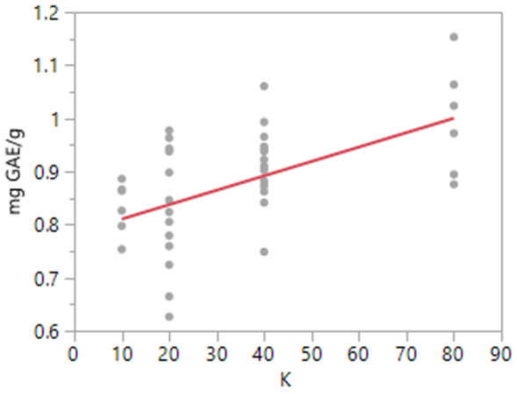


R^2=0.480; P≤0.000

- Total polyphenol contents increased with increasing phosphorus in the white cultivar, but decreased in the red cultivar.

- Total polyphenol contents was previously reported to increase with phosphorus fertilization in wheat.

K Fertilization effect on polyphenol contents-Pot

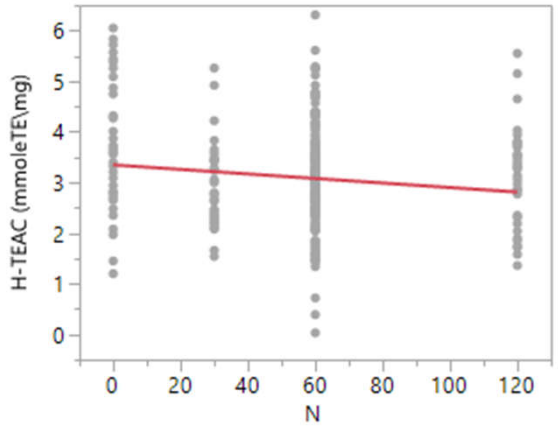


R^2=0.300; P≤0.000

- Increasing potassium increased total polyphenol contents in pot.

- Both cultivars had similar response.

Fertilization effect on AO capacity in teff



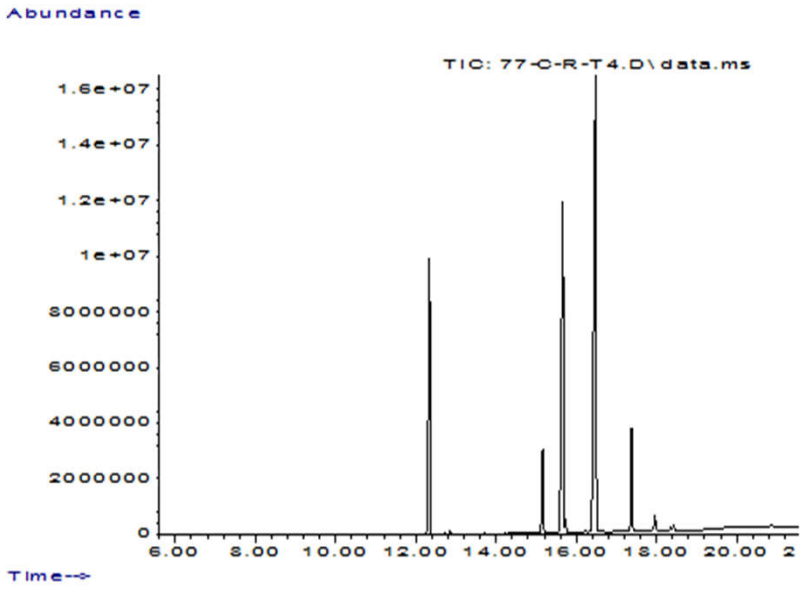
Hydrophilic AO- N effect
R^2=0.019; P≤0.014

- **N, P and K did not affect anti oxidative capacity of teff grains.**

This response was consistent in both cultivars.

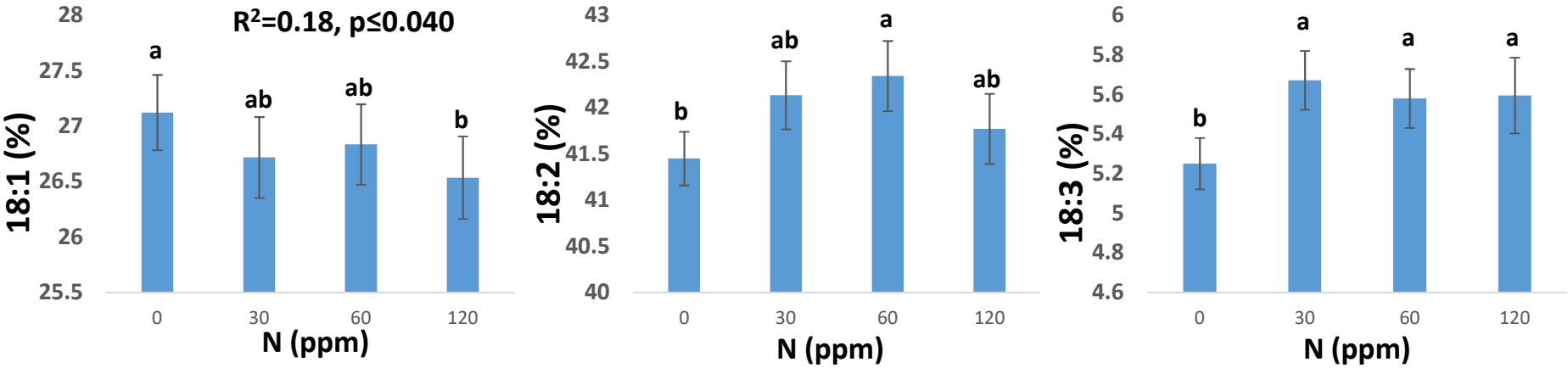
Teff fatty acid composition

Fatty acid	%
16:0	16.4±0.35
16:1 (*Z*-)	0.17±0.00
18:0	5.26±0.08
18:1 oleic	26.83±0.28
18:2 linoleic	42.34±0.17
18:3 linolenic	5.58±0.07
20:0	1.05±0.07
20:1	0.34±0.03
21:0	0.28±0.03
22:0	1.73±0.140.96



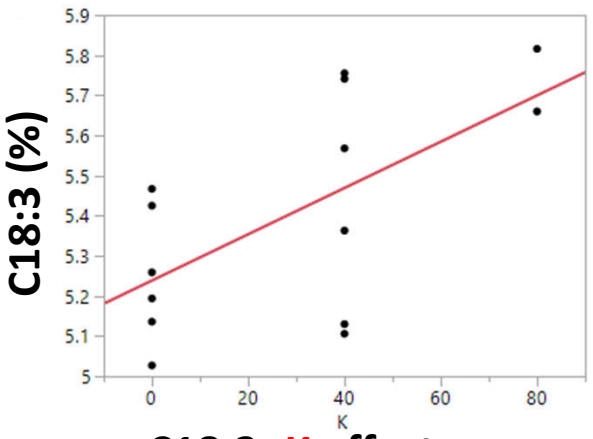
Nitrogen effect on teff fatty acid composition

We observed a consistent effect on C18 fatty acid levels



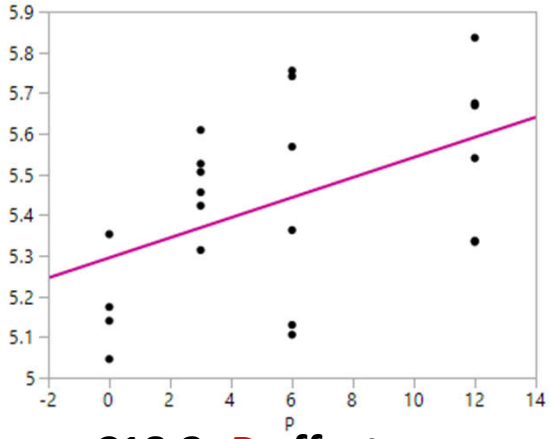
- Higher nitrogen fertilization resulted in a decrease in mono unsaturated fatty acid levels, and in an increase in poly unsaturated fatty acids.

Fertilization effect on C18:3



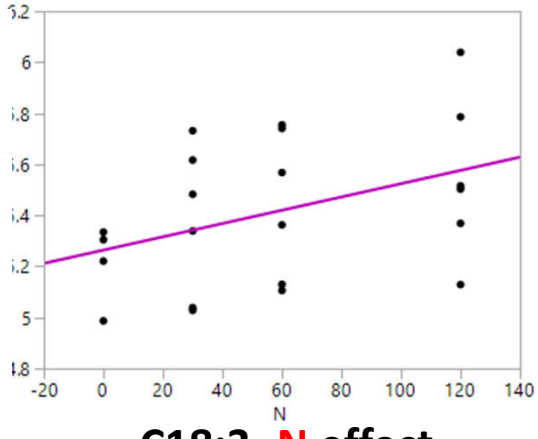
C18:3- K effect

R^2=0.384; P≤0.018



C18:3- P effect

R^2=0.229; P≤0.024



C18:3- N effect

R^2=0.160; P≤0.054

- We observed a consistent effect on C18:3- an important poly unsaturated ω-3 fatty acid.
- Poly unsaturated fatty acids increase stress tolerance, but are easily oxidized.
- Might imply stress conditions in high fertilization.

Additional quality parameters

1. Sensory quality:

    a. Aroma

    b. Taste

    c. Texture

2. Flour and dough quality:

    a. Protein

    b. Fiber

Concluding remarks and further research

- Fertilization affects teff health and nutritional value, including mineral contents, total polyphenol contents and fatty acid profile.
- These effects should be considered when choosing growth conditions.
- More research is required to characterize the effect of cultivar and cultivation area on Israeli teff.
- Other quality aspects, mainly organoleptic, are important to consumers.

Acknowledgements

Yermiyahu Group

Kelem Gashu

Ella Simhon

ICL – CFPN funding

ICA funding

CFPN Center for Fertilization and Plant Nutrition
ARO and ICL initiative

יק"א בישראל
ICA in Israel
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