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"REUSE OF WASTED BREAD, BIOPROCESSED AND NOT, AS SOIL AMENDMENT"

Claudio Cacace, Carlo G. Rizzello, Michela Verni, Gennaro Brunetti, Claudio Cocozza

claudio.cacace@uniba.it

UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

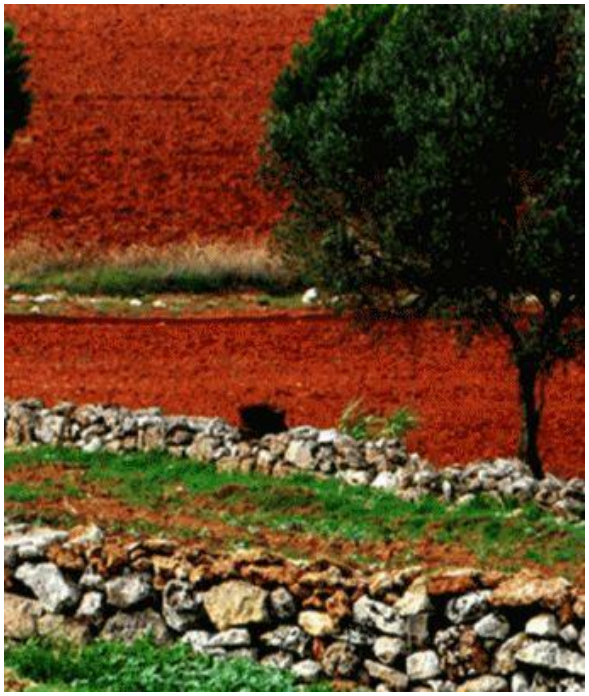
Introduction

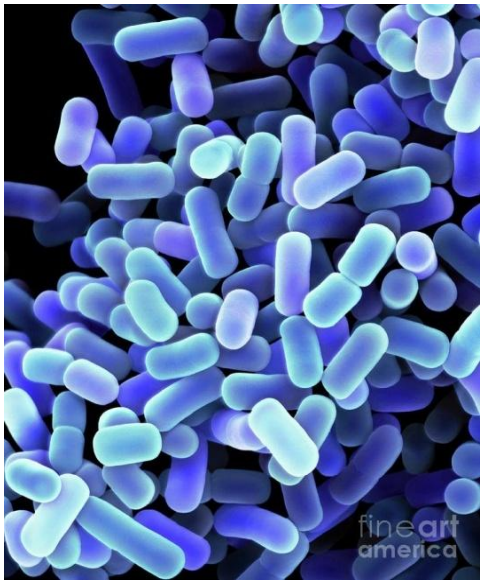
Among some Mediterranean countries, bread and bakery products represent up to 20% of the total daily food waste produced by some surveyed consumers (Capone et al., 2016).

Melikoglu and Webb (2013) estimated that the bread wasted daily is around hundreds of tons worldwide, and only a little quantity is reused mainly to feed livestock.

WB can be bioprocessed with lactic acid bacteria (LAB) for obtaining starters for food industry and new amendments

Introduction





Since LAB cause a fast acidification through the production of organic acids, an acidified biomass, applied as soil amendment, could be of interest for the alkaline soils, such as the Mediterranean ones. In such pH conditions many essential plant nutrients are not so available for the crops, e.g., phosphorous precipitates as Ca phosphates (Sposito, 2008) but the competition for the sorption sites between P and organic acids helps to increase the P availability (Brunetti et al., 2019).

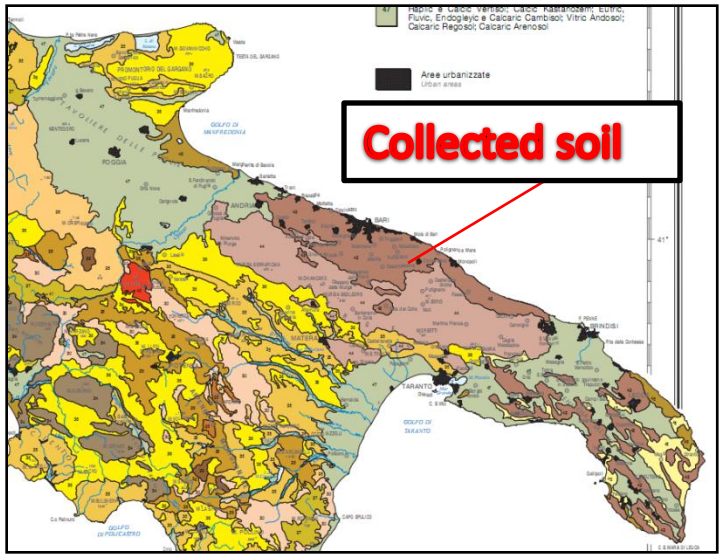
This work aimed at investigating the potential of wasted bread to be used as organic soil amendment.

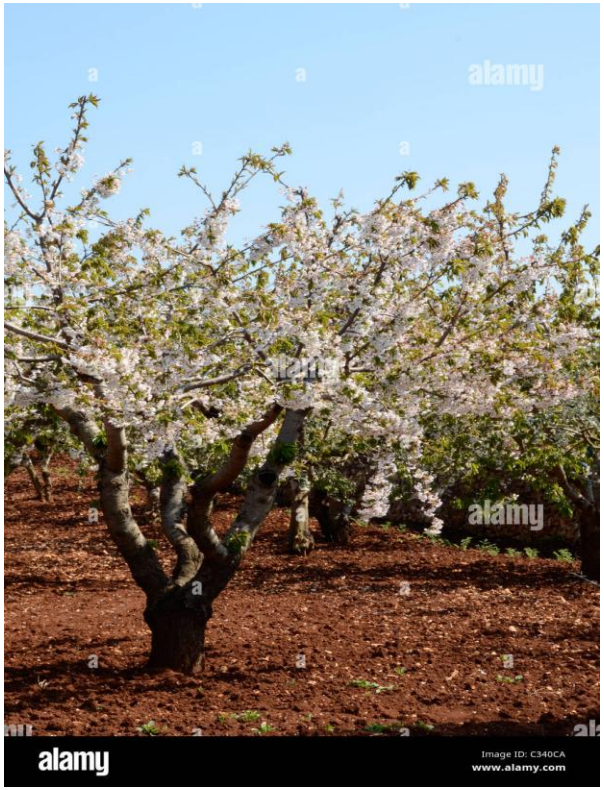
A bioprocessed wasted bread (bWB), obtained by an enzymatic treatment coupled with fermentation, and containing viable LAB (*Lactiplantibacillus plantarum* H64) cells at high cell density, together with a biomass of unprocessed wasted bread, were included in this study and used in a pot-trial.

An integrated analytical plan aimed at assessing :

- The modification of the physicochemical properties of a typical Mediterranean alkaline agricultural soil;
- The plant growth-promoting effect on escarole (*Cichorium endivia* var. *Cuartana*), used as indicator crop, was carried out.

An alkaline soil was collected from a stone fruits orchard, air dried and used for the pot experiment.





Treatments included in the pot-experiment were:

i) not amended soil, without plant (CTA);
ii) soil amended with WB, without plant (WBA);
iii) soil amended with bWB, without plant (bWBA);
iv) not amended soil, with plant (CTP);
v) soil amended with WB, with plant (WBP);
vi) soil amended with bWB and with plant (bWBP).

Materials & Methods

Pots were distributed in a completely randomized design with three replications for each treatment, for a total of 18 experimental pots, and the trial was performed in a cold greenhouse at the University of Bari (South Italy).

The amended pots received WB or bWB at a dose of about 25000 kg ha^{-1}, according to the good agricultural practices.

Results & Discussion

Table 1. Chemical and physicochemical characteristics of WB and bWB

Samples	Ash %	Moisture %	pH (H_2O)	EC µS cm^{-1}	C. Org %	N. Tot %	P tot. mg kg^{-1}	C/N
WB	0.73 ± 0.05	61.81 ± 6	5.20 a	1950 ± 50 a	40.7 ± 1 b	2,47 ± 0.04 a	1716 ± 246	16.4 ± 0.07 b
bWB	0.86 ± 0.06	65.04 ± 5	3.74 b	1820 ± 60 b	43.7 ± 2 a	2,25 ± 0.02 b	2150 ± 15	19.4 ± 0.03 a
HSD.test	**ns**	**ns**	***	*	*	*	ns†	**

The values in each column followed by a different letter are significantly different according to HSD. test or Kruskal Wallis (†). * Significant at $p \leq 0.05$; ** Significant at $p \leq 0.01$; *** Significant at $p \leq 0.001$; ns: not significant.

Results & Discussion

Table 2. Properties of soils with plants at the end of the trial compared to T0

Samples	pH_{H2O}	pH_{KCl}	EC $\mu S\ cm^{-1}$	OC $g\ kg^{-1}$	TN $g\ kg^{-1}$	P_{ava} $mg\ kg^{-1}$
T0	8.20 ± 0.15 a	7.20 ± 0.08	200 ± 7 c	16 ± 0.45 b	1.60 ± 0.10 bc	45.5 ± 1
CTP	8.07 ± 0.05 a	7.25 ± 0.01	417 ± 103 b	17.5 ± 0.49 b	1.31 ± 0.26 c	46.1 ± 2.2
WBP	7.67 ± 0.09 b	7.25 ± 0.11	685 ± 109 a	22.4 ± 1.23 a	1.96 ± 0.11 ab	48 ± 7.9
bWBP	7.57 ± 0.01 b	7.23 ± 0.07	786 ± 56 a	22.4 ± 0.83 a	2.17 ± 0.16 a	41.9 ± 1.8
HSD.test	***	ns	***	***	**	ns†

The values in each column followed by a different letter are significantly different according to HSD. test or Kruskal Wallis (†).

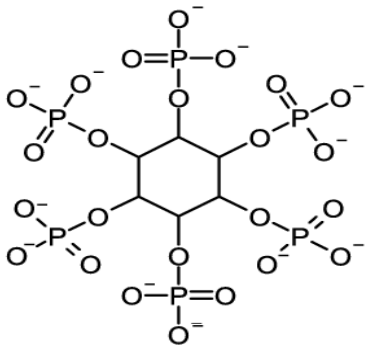
* Significant at $p \leq 0.05$; ** Significant at $p \leq 0.01$; *** Significant at $p \leq 0.001$; ns: not significant.

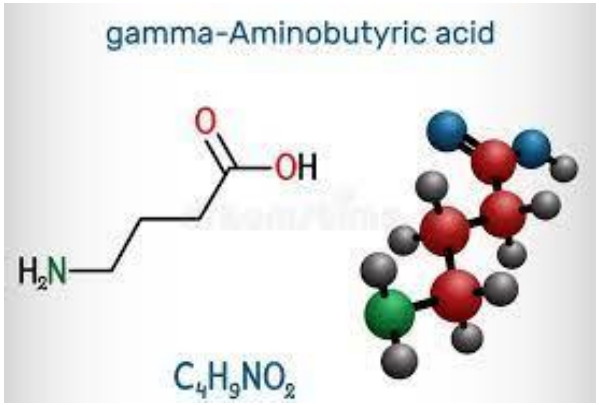
Results & Discussion

Table 3. Chemical and physicochemical properties of CTR, WBA and bWBA soils

Samples	pH_{H_2O}	pH_{KCl}	EC $\mu S\ cm^{-1}$	OC $g\ kg^{-1}$	TN $g\ kg^{-1}$	P_{ava} $mg\ kg^{-1}$
T0	8.20 ± 0.15 a	7.20 ± 0.08	200 ± 7 b	16.0 ± 0.45 b	1.6 ± 0.10 bc	45.5 ± 1 ab
CTR	8.20 ± 0.08 a	7.30 ± 0.08	319 ± 57 b	15.2 ± 0.51 b	1.5 ± 0.07 c	46.9 ± 1.9 a
WBA	7.70 ± 0.07 b	7.30 ± 0.04	805 ± 109 a	20.3 ± 1.47 a	2.1 ± 0.18 a	37.3 ± 2.5 bc
bWBA	7.70 ± 0.07 b	7.20 ± 0.02	764 ± 22 a	20.8 ± 0.23 a	1.9 ± 0.12 ab	36.1 ± 2 c
HSD.test	***	ns	***	***	**	**

The values in each column followed by a different letter are significantly different according to HSD. Test.
* Significant at $p \leq 0.05$; ** Significant at $p \leq 0.01$; *** Significant at $p \leq 0.001$; ns: not significant.





Results & Discussion

Table 4. Soil availability of selected micronutrients in cultivated pots

	Mn	Fe	Cu
Samples		**mg kg^{-1}**	
CTP	10.72 ± 0.85 b	2.08 ± 0.08 b	1.24 ± 0.02 b
WBP	16.77 ± 1.65 a	2.87 ± 0.32 a	1.36 ± 0.05 ab
bWBP	16.68 ± 2.83 a	3.15 a ± 0.21 a	1.43 ± 0.07 a
HSD.test	*	**	*

Table 5. Soil availability of selected micronutrients in uncultivated pots

	Mn	Fe	Cu
Samples		**mg kg^{-1}**	
CTR	8.06 ± 0.34 b	2.02 ± 0.05 b	1.23 ± 0.01
WBA	22.04 ± 6.20 a	2.88 ± 0.48 a	1.37 ± 0.07
bWBA	20.88 ± 1.90 a	2.85 ± 0.32 ab	1.49 ± 0.31
HSD.test	**	*	ns

The values in each column followed by a different letter are significantly different according to HSD. test Significant at $p \leq 0.05$; ** Significant at $p \leq 0.01$; *** Significant at $p \leq 0.001$; ns: not significant.

Results & Discussion

Table 6. Micronutrients and phosphorous content expressed as mg kg^{-1}, of escarole leaves grown in control soil (CTP), soil amended with wasted bread (WBP), and soil amended with bioprocessed wasted bread (bWBP), treated with amylase and fermented with *Lactiplantibacillus plantarum* H64).

Sample	B	Mn	Fe	Cu	P
CTP	15.45 ± 3.85 a	0.74 ± 0.25	14.77 ± 6.60	0.16 ± 0.03	358 ± 111 a
WBP	7.36 ± 0.96 b	0.76 ± 0.06	15.31 ± 2.93	0.15 ± 0.01	131 ± 50 b
bWBP	2.13 ± 2.52 b	1.06 ± 0.26	10.61 ± 3.24	0.13 ± 0.01	144 ± 29 b
HSD.test	**	ns	ns	ns	*

Results & Discussion

CTP

WBP

bWBP

Table 6. Biometric features of plants at the end of the trial

Samples	Number of Leaves per Plant	Treated/CTP leaves ratio	Average Head Escarole Fresh Weight (g)	Treated/CTP yield ratio
CTP	13 ± 1.15 b	-	6.6 ± 0.47 b	-
WB P	22 ± 3.78 a	1.69 ± 0.40	12.9 ± 0.95 a	1.95 ± 0.22
bWBP	19 ± 3.05 ab	1.46 ± 0.15	11.2 ± 1.36 a	1.69 ± 0.11
HSD.test	*	**ns**	***	**ns**

Results & Discussion

Figure 1. Effect of the biomasses on chlorophyll content of escaroles.

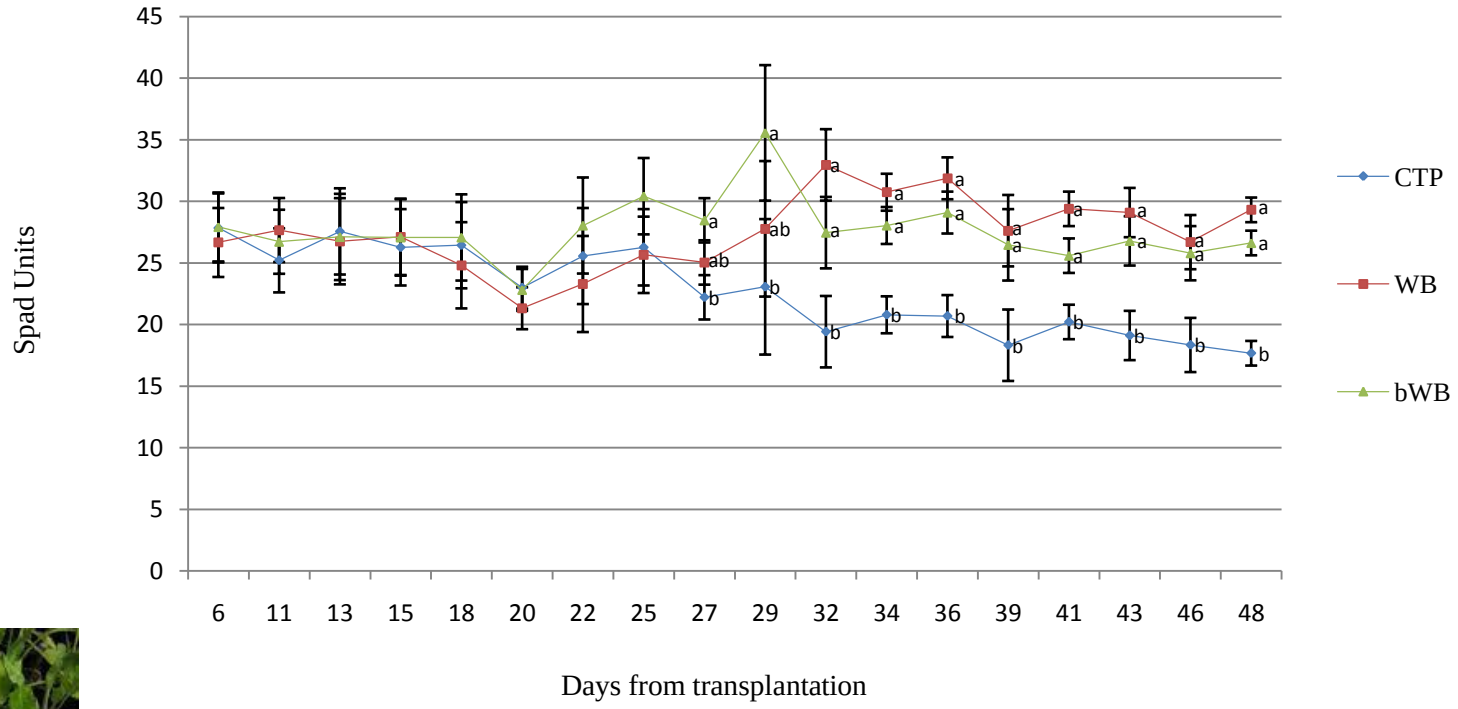
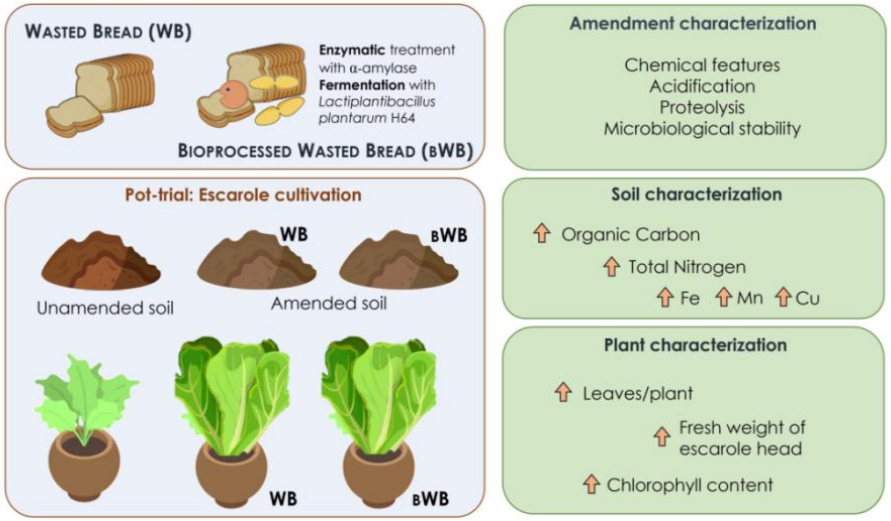


Figure 1. Effect of the biomasses on chlorophyll content of escaroles grown in control soil (CTR), soil amended with wasted bread (WB), and soil amended with bioprocessed wasted bread (bWB, treated with amylase and fermented with *Lactiplantibacillus plantarum H64). a–b Different letters* indicate significant differences among the data according to the HSD test. Vertical bars represent the standard deviation.

Conclusions



Application of WB and bWB resulted in higher escarole yield with respect to the unfertilized control without any apparent phytotoxicity thus confirming the possible re-utilization as promising biomasses in agriculture as amendments. The use of wasted bread fermented with LAB apparently resolved the transplantation stress sooner, and further investigation are needed about the effects of such pre-treatment on the standardization of biomass characteristics and on its shelf life.

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Thank you for your attention!

Claudio Cacace

claudio.cacace@uniba.it

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