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CQA-Tested Green Bin Compost: 5-Year Research Results

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WHY GREEN BIN/MSW COMPOST?

- Total global cost of solid waste management in 2010 was $205.2 billion
- This will increase to *ca*. $375 billion in 2025 (World Bank, 2017)
- 30–64% of the total MSW constitute biodegradable organic materials...a ready supply of raw materials for composting
- Composting offers an immediate solution to the problem of:
  - "wasting" organic materials for recycling soil OM and soil nutrients needed for plant growth

Why MSW compost?

- The benefits of MSW compost are well known but not completely accepted, especially for food production due to contamination concerns
- Another main set back is that the specific effect of MSW compost on food quality and safety is understudied
- These have slowed down global adoption of MSW compost
- So, what about long-term application of CQA-tested MSW compost?

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PROJECT OBJECTIVES

- Overall objective:
  - To support the advancement of CQA-tested MSW compost markets in MB and Canada

- Specific objective:
  - To determine the application frequency of CQA-tested MSW compost on soil quality, plant growth, harvest quality and economic benefit

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The Trial

- 5-year research at Aagaard Farms, Brandon MB (Lat. 49.848, Long. -99.950)
- Climate is dominantly cool to moderate cool, Boreal, sub-humid continental
- Soil: Newdale series and characterized by an Orthic Black Chernozem solum
- CQA-tested MSW compost from the City of Brandon facility
- Lettuce (*Latuca sativa* cv. Grand Rapids), beets (*Beta vulgaris* cv. Detroit Supreme), carrot (*Daucus carota* cv. Nantes), green beans (*Phaseolus vulgaris* cv. Golden Wax)
- Treatments: No compost, Annual & Biennial applications
- RCBD with three replications (plot sze: 3 m x 6 m)

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The Big Data

- Soil physico-chemical data
- Plant morpho-physiological data
- Metagenomics (microbial) data
- Metabolomic data for untargeted plants metabolites

RESULTS

Soil Properties

- Physical
- Chemical
- Microbial community

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Table 1. Selected physical and hydrological properties of soil after five years of application of CQA-tested green bin compost at different frequencies.

Hydrological properties	Treatment		
	Annual	Biennial	Control
WHC (%)	69.58a	59.80b	47.20c
Saturation capacity (%)	49.33a	46.39a	39.65b
Field capacity (%)	41.24a	35.37ab	30.49b
Wilting capacity (%)	6.40a	4.69ab	4.16b
Bulk density (g/cm^3)	0.99b	1.06b	1.22a
Particle density (g/cm^3)	1.22c	1.33b	1.41a

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Figure 1. Soil equivalent N release, SOM, CEC and pH.

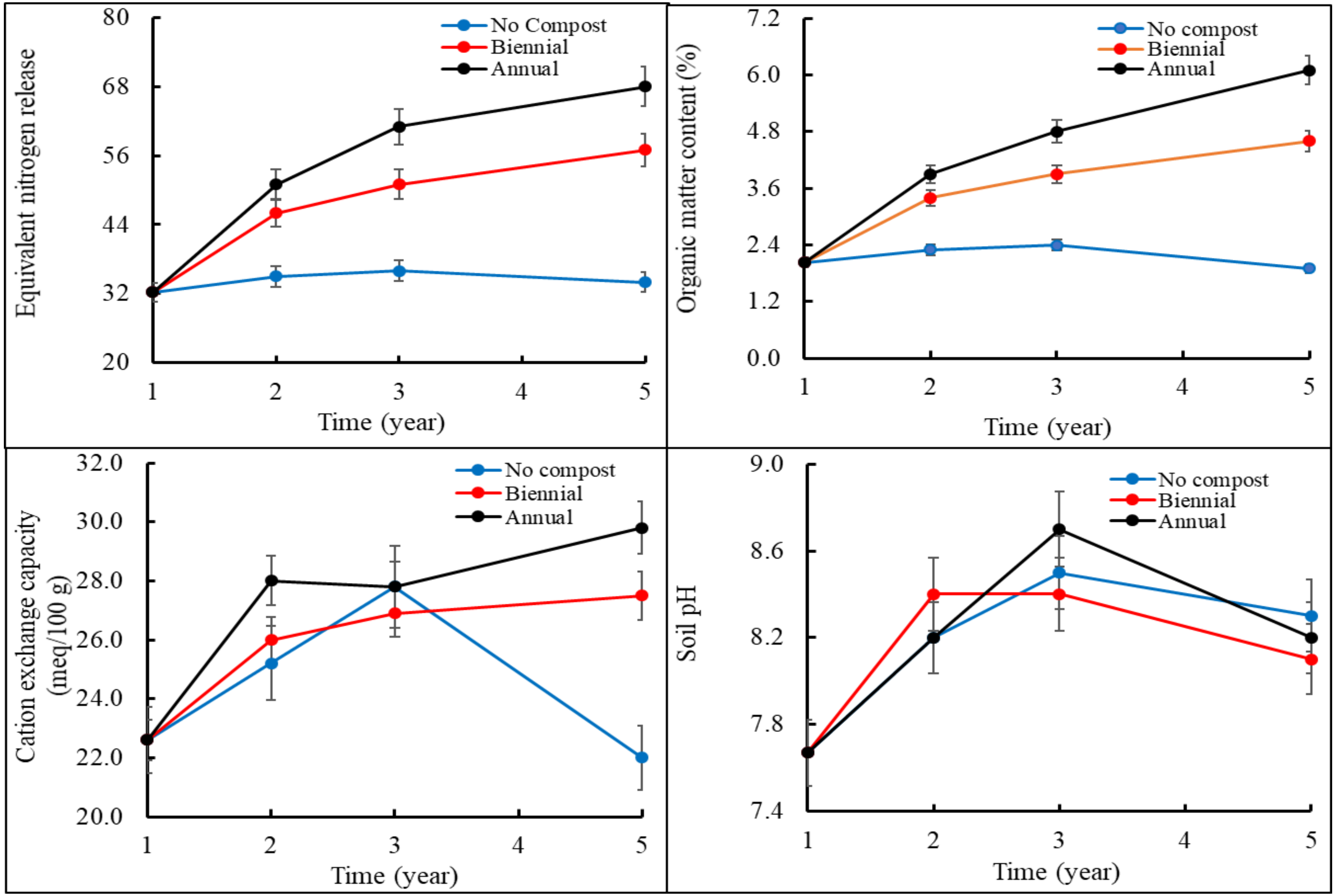

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Figure 2. Mineral Element accumulation in soil.

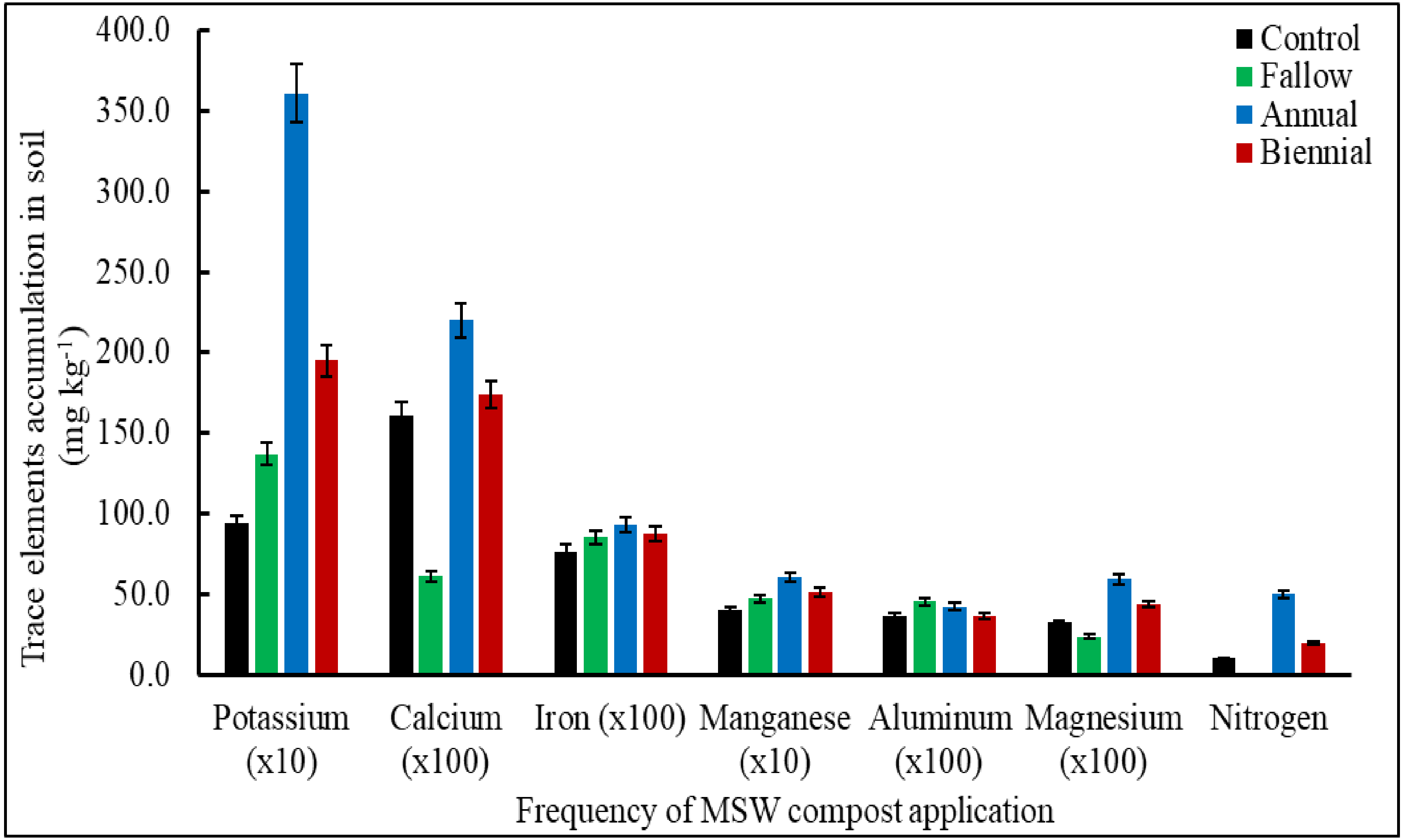

Figure 3. Change in Soil Mineral Nutrients

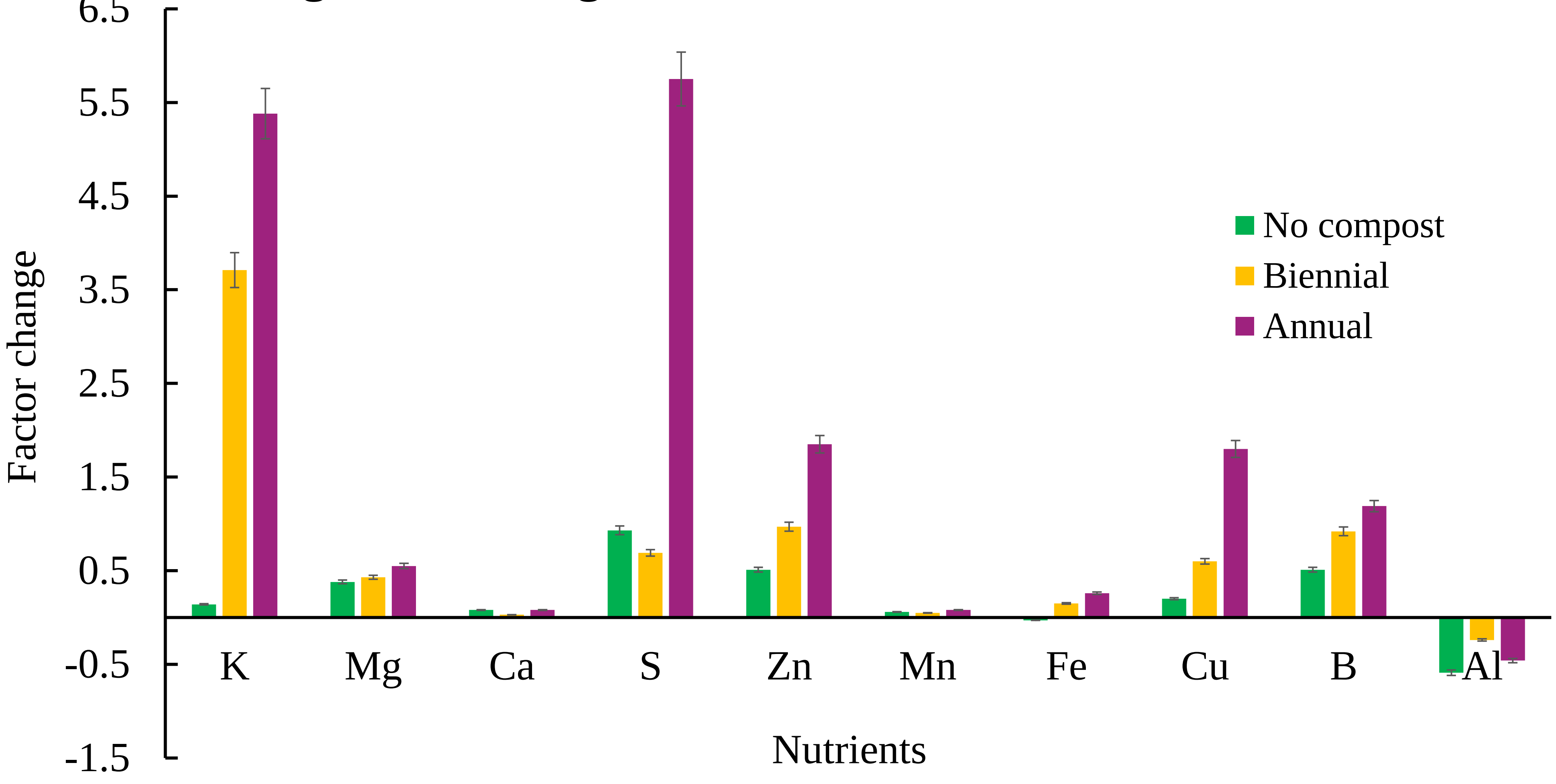

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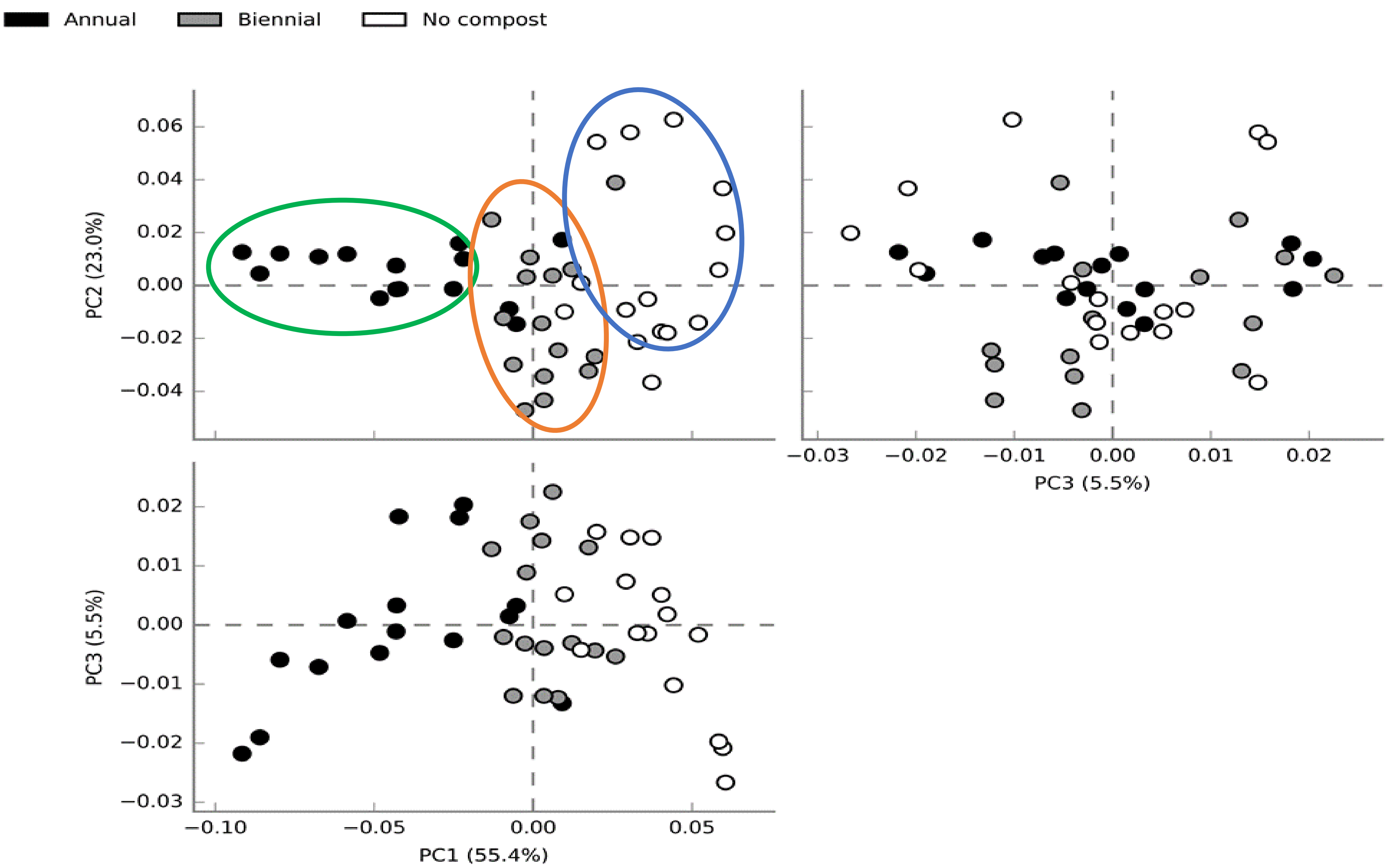
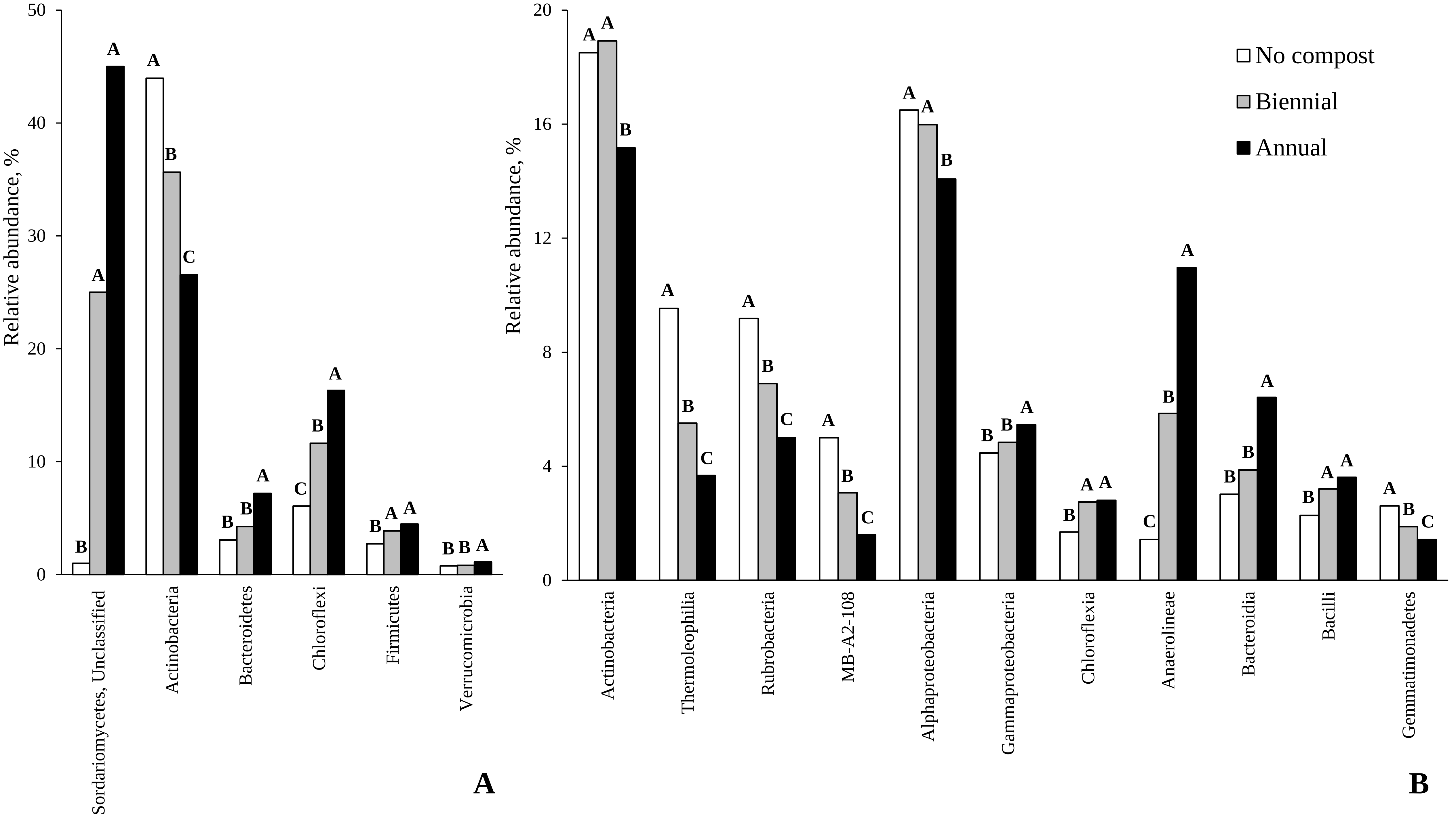
Figure 4. Microbial distribution in soil.





Relative abundance, %
50
40
30
20
10
0
B A A
A B C
B B A
C B A
B A A
B B A
Sordariomycetes, Unclassified
Actinobacteria
Bacteroidetes
Chloroflexi
Firmicutes
Verrucomicrobia
A
20
16
12
8
4
0
No compost
Biennial
Annual
A A B
A B C
A B C
A B C
A A B
B B A
B A A
C B A
B B A
B A A
A B C
Actinobacteria
Thermoleophilia
Rubrobacteria
MB-A2-108
Alphaproteobacteria
Gammaproteobacteria
Chloroflexia
Anaerolineae
Bacteroidia
Bacilli
Gemmatimonadetes
B

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- Annual compost application contributed to 52% and 9% of the variations in bacterial and fungal communities, respectively
- Biennial compost application did not significantly affect fungal microbiome structure and had minor but significant effect on bacterial microbiome

Plant health and yield

- Chlorophyll
- Anthocyanin
- Growth
- Yield

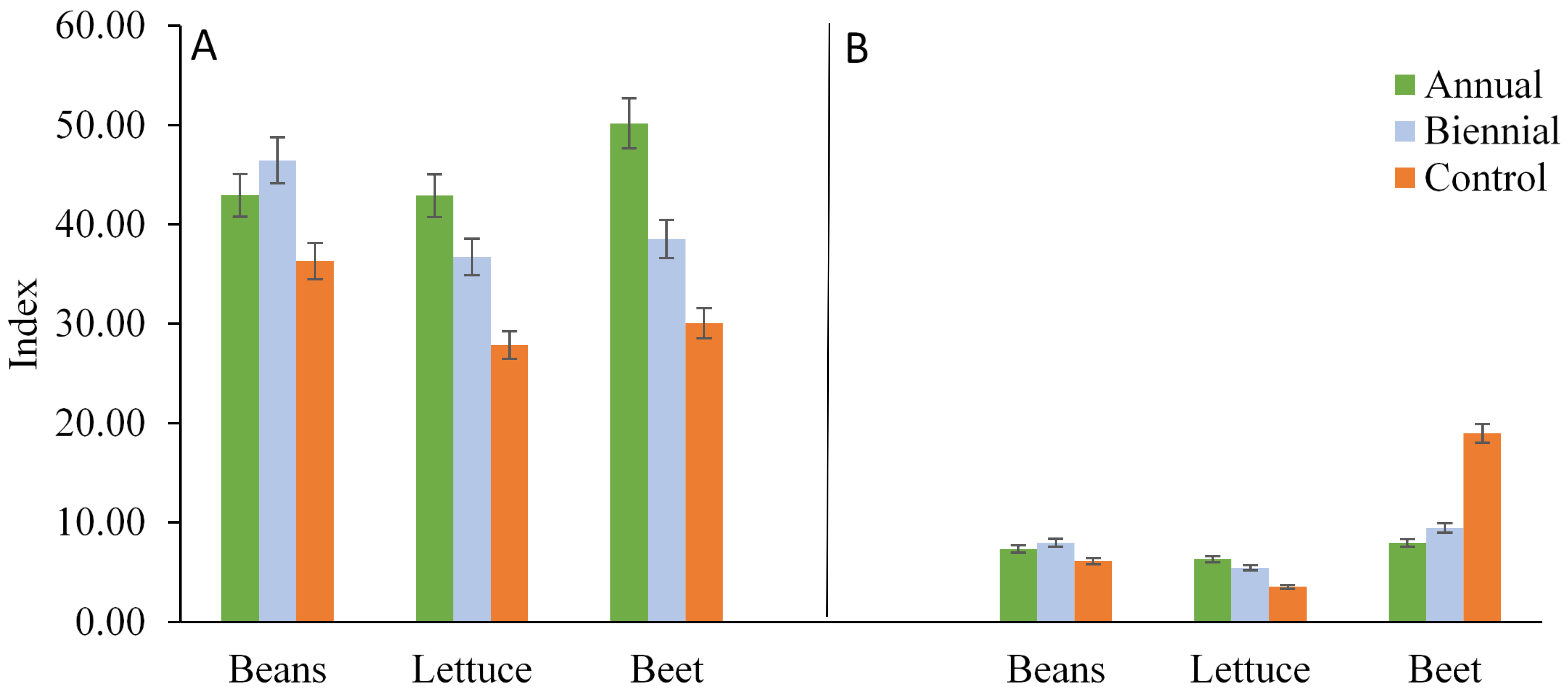

Fig. 2. Chlorophyll (A) and anthocyanin (B) contents of plants leaves as affected by CQA-tested compost applied annually, biennially and no compost application at the end of a 5-year period.

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Figure 6. Size distribution of the carrots, green beans, lettuce and beets.

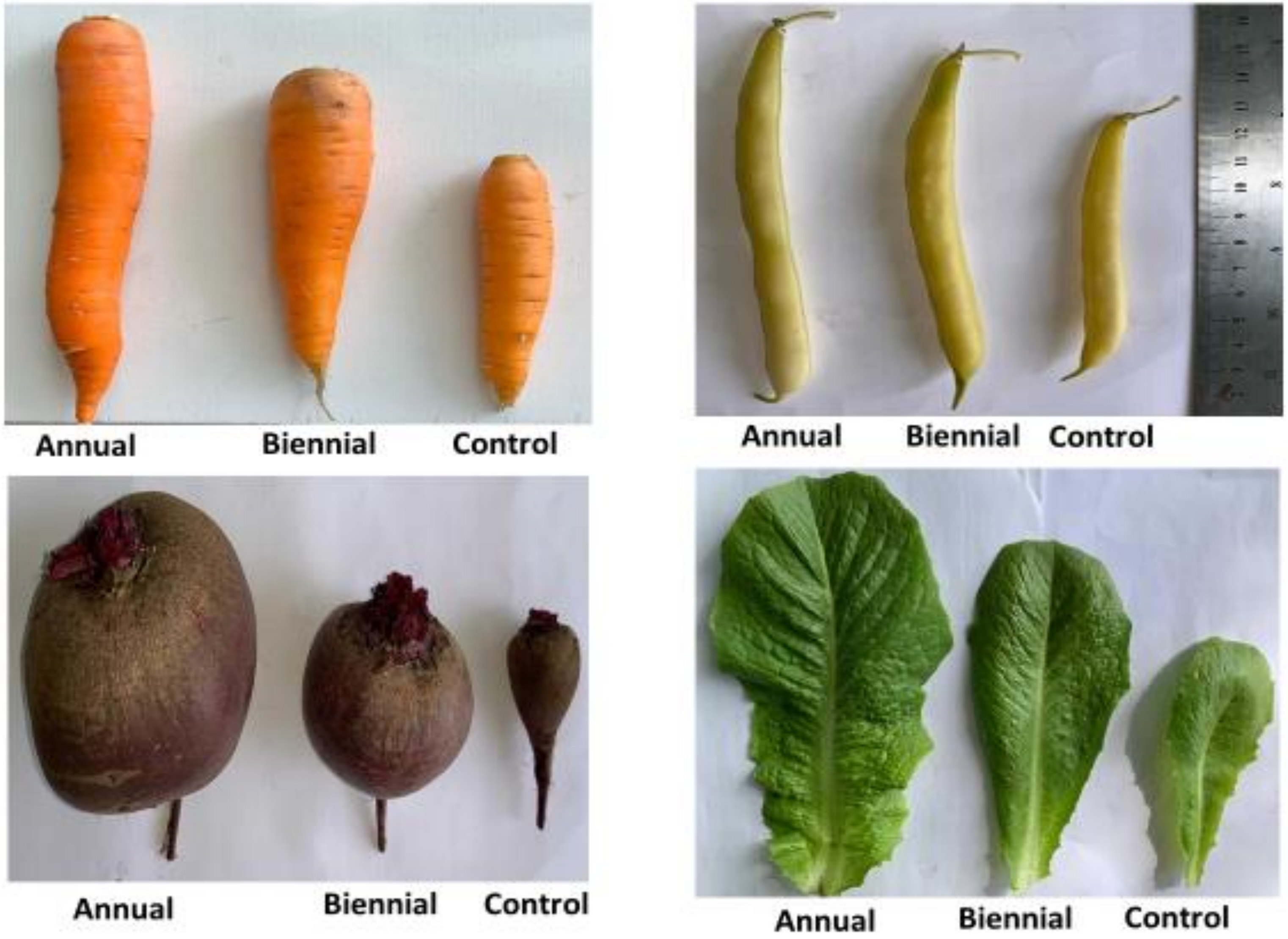
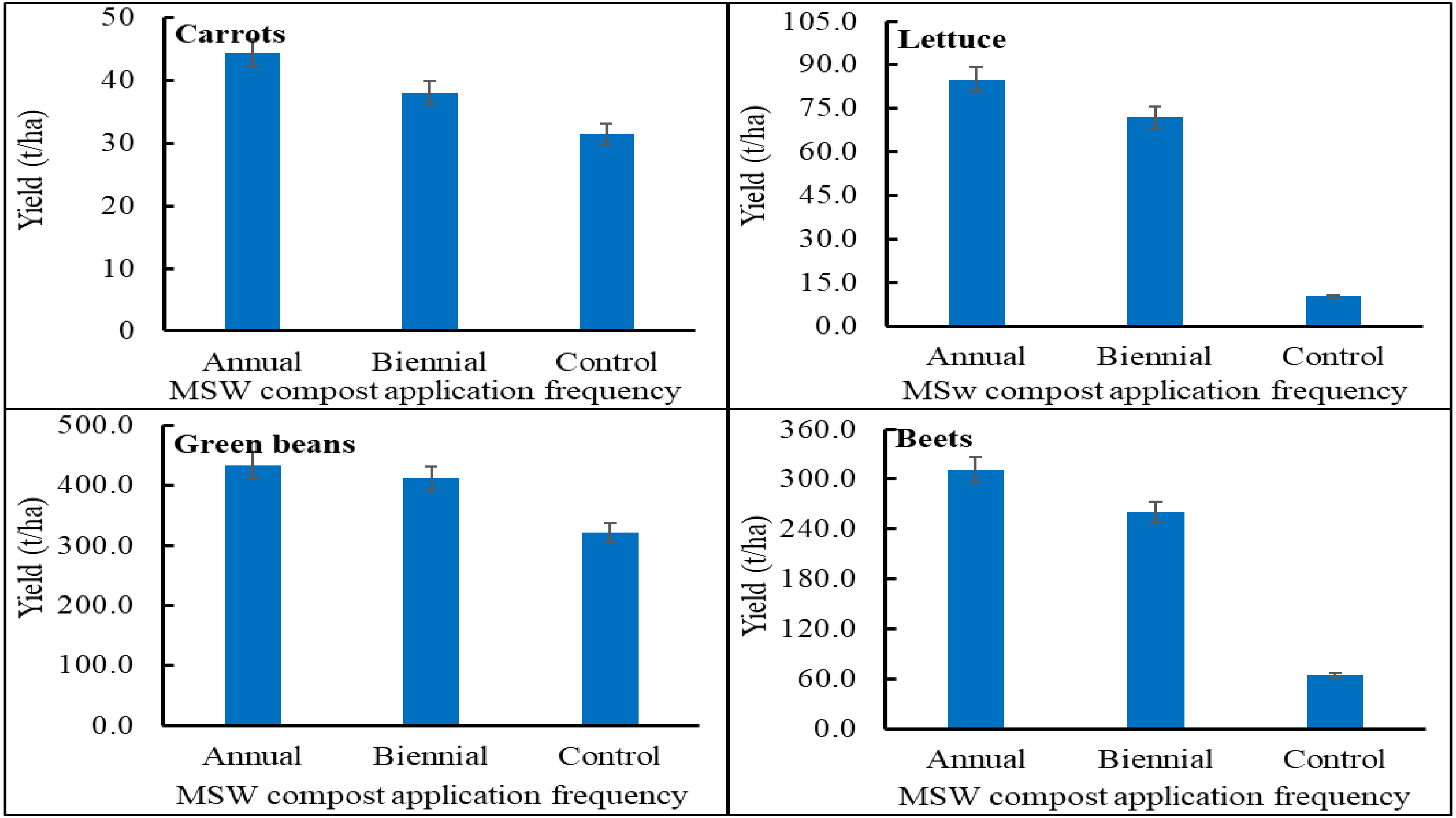


Figure 7. Yield of carrots, lettuce, beets and green beans in Year 5.



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Total Metabolites Composition

- Glucose
- Acylcarnitines
- Phospholipids
- Choline
- Essential amino acids

Figure 8. Total glucose contents of the four harvested crops.

- Glucose is the major source of energy for the body cells
- Glucose is converted to sucrose, cellulose, lipids, proteins and stored as starch

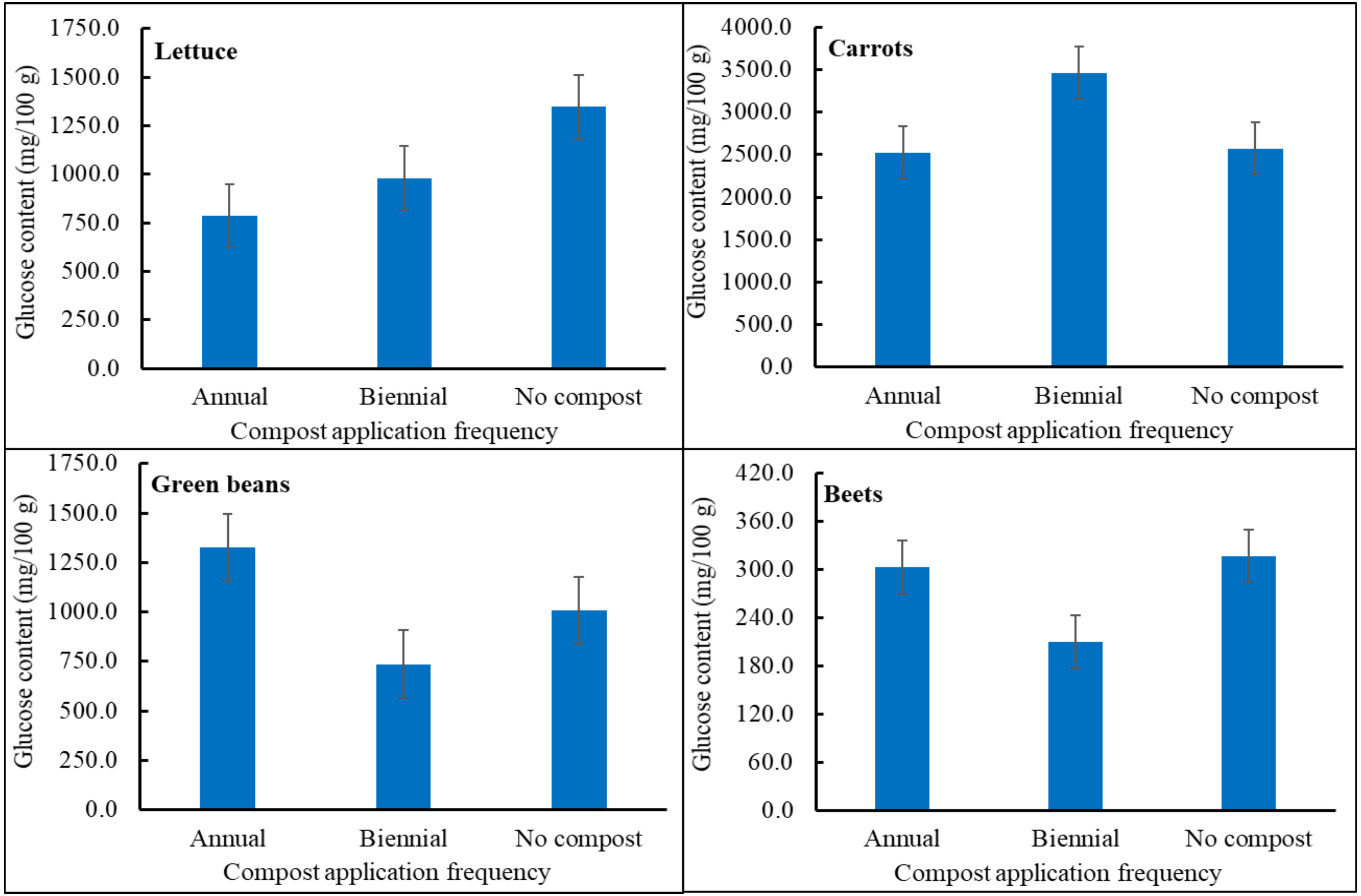

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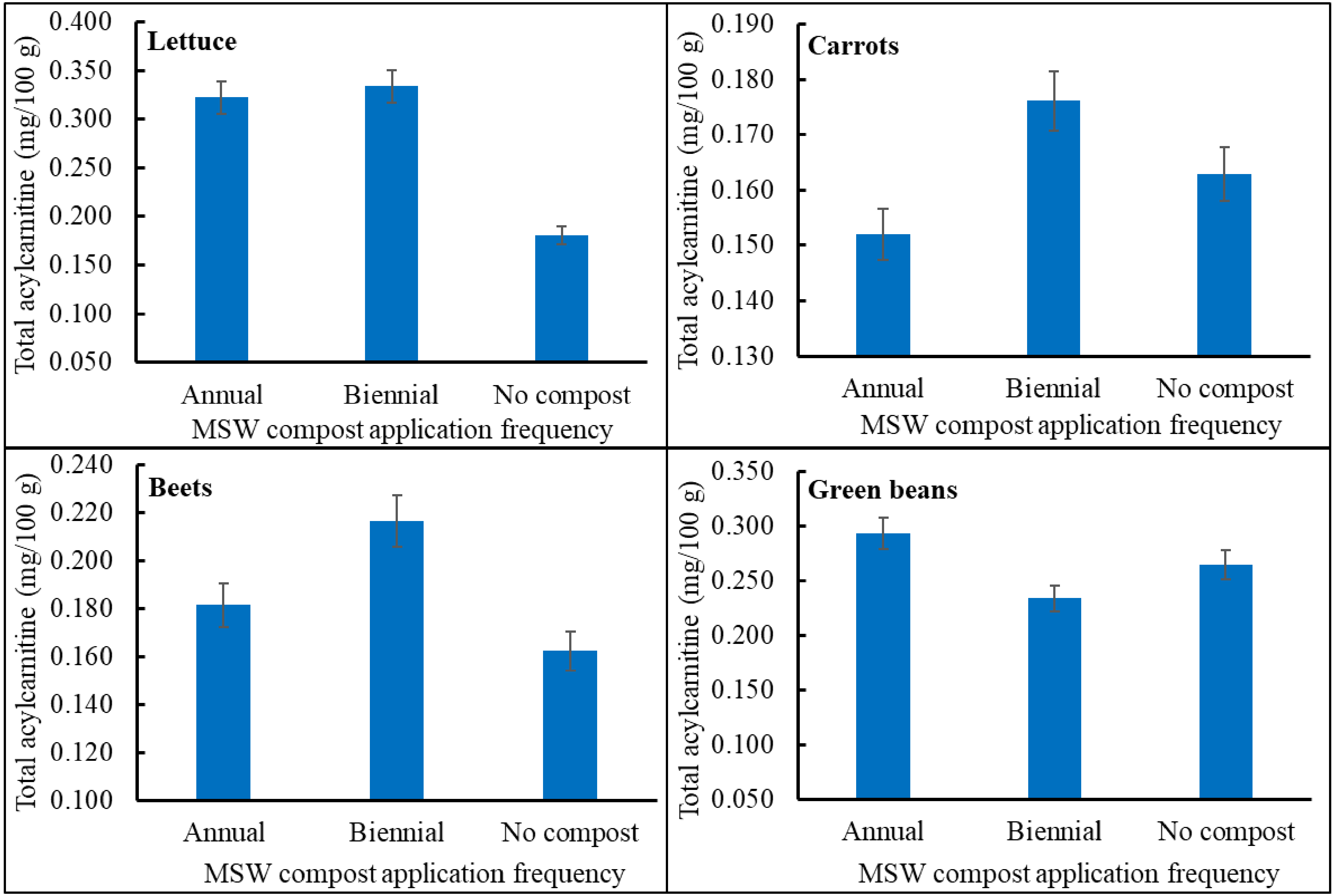
Figure 9. Total acylcarnitines contents of the four harvested crops.

- Acylcarnitines are derivatives of long-chain fatty acids
- Required for fatty acids transportation into mitochondria for β-oxidation
- Play an important role in plants resistance to metals
- They support membranes of cell organelles



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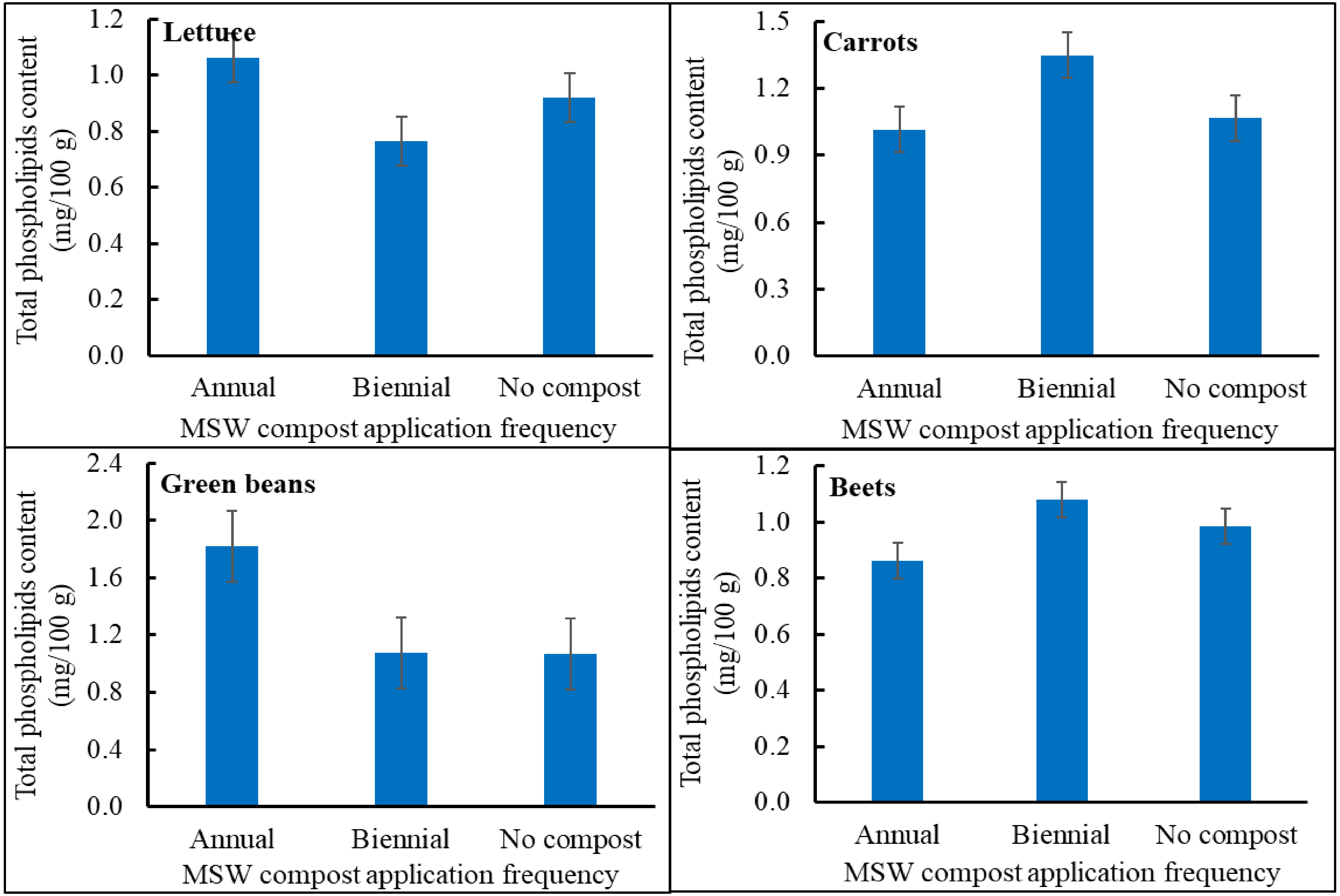
- Lysophospholipids play crucial biological roles, mainly as signaling molecules
- They affect growth, survival, migration and activation of many cell types
- Lysophosphatidic acid and lysophosphatidylcholine are increasingly linked with atherosclerosis and anti-inflammatory effects

Figure 10. Total phospholipids content of the four harvested crops.



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- Choline is an essential nutrient, naturally present in some foods
- It is a source of methyl groups for many steps in metabolism
- Vital roles in modulating gene expression, cell membrane signaling, lipid transport and metabolism, and early brain development

Figure 11. Choline contents of the four harvested crops.

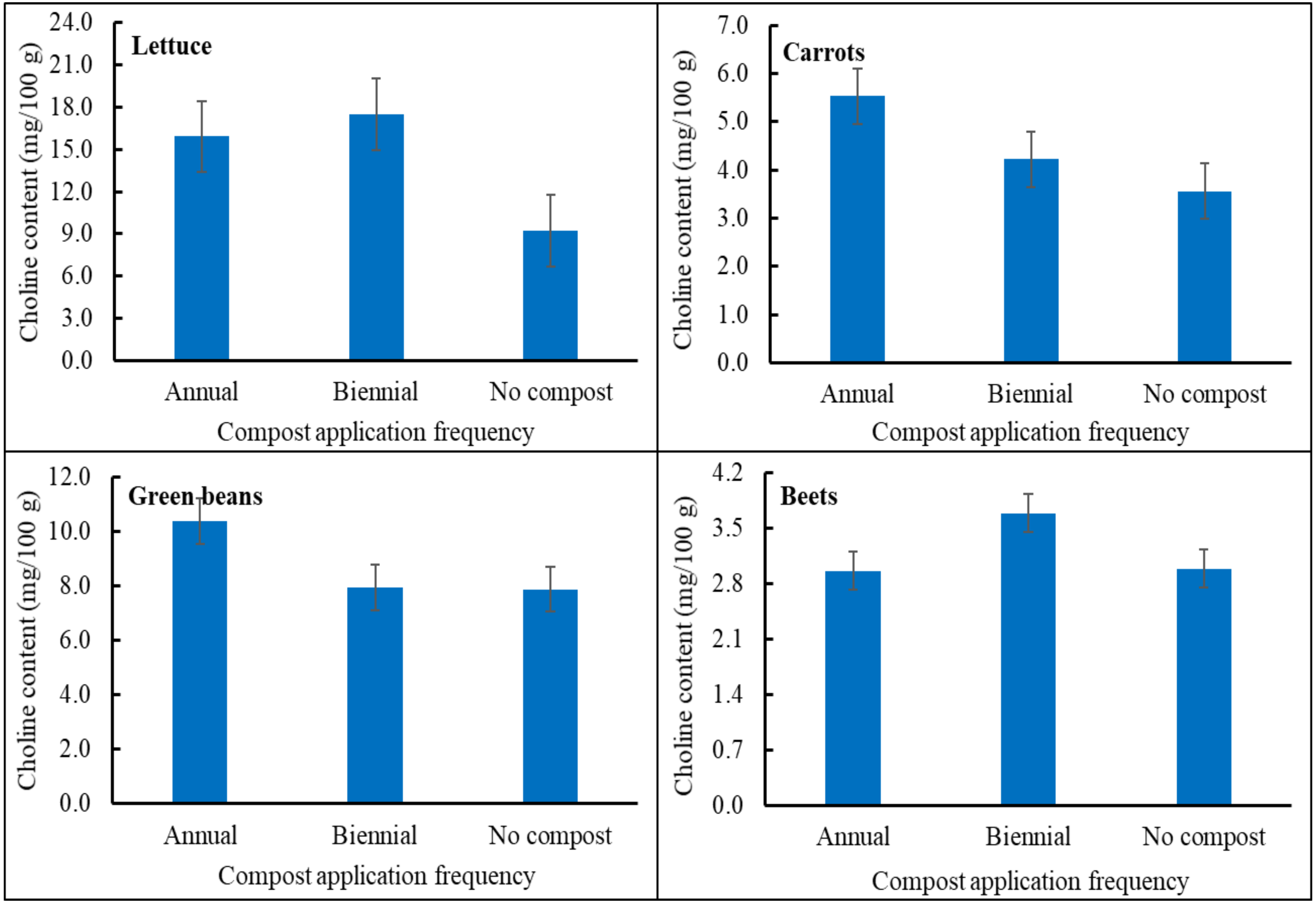

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Table 1. Roles of the nine essential amino acids.

Amino acid	Role
Isoleucine	Formation of hemoglobin; prevents muscle wasting in debilitated individuals
Leucine	Promotes healing of skin and broken bones; reduces muscle protein breakdown
Valine	Influences brain uptake of other neurotransmitter precursors (tryptophan, phenylalanine and tyrosine)
Histidine	Production of red and white blood cells; treatment of anemia
Lysine	Inhibits viruses; treatment of herpes simplex, Lysine and Vitamin C together form L-carnitine, a biochemical that enables muscle tissue to use oxygen more efficiently, delaying fatigue
Methionine	Increases the antioxidant levels (glutathione); reduces blood cholesterol levels
Phenylalanine	Production of collagen, precursor of tyrosine; enhances learning, memory, mood and alertness
Threonine	Prevents fatty build up in the liver; amino detoxifers
Tryptophan	Prevents fatty buildup in the liver; precursor of key neurotransmitter serotonin, which exerts a calming effect

http://www.phcogrev.com/viewimage.asp?img=PhcogRev_2013_7_14_107_120508_t1.jpg

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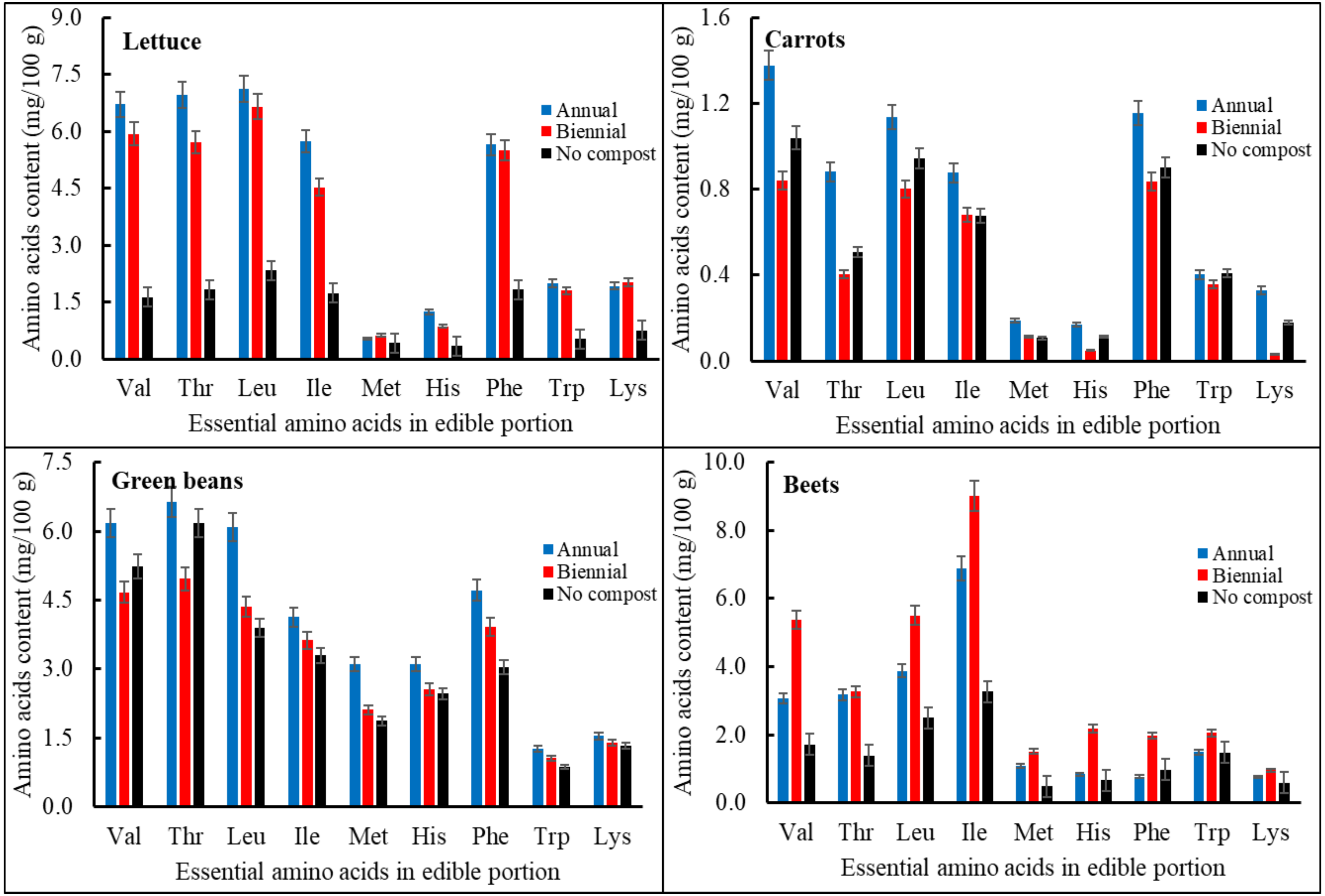
Figure 12. The nine essential amino acids contents in the four harvested crops.

- Amino acids are the building blocks of proteins
- The nine essential amino acids are involved in tissue growth, energy production, immune function and nutrients absorption



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Bioaccumulation Factor for Trace Elements in Edible Portions

- BAF rating for metals:
  - Below 1 were considered excluders
  - Between 1 – 10 were considered as accumulator metals
  - Hyperaccumulators had values >10 (Reddy et al., 2018)

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Table 13. Bioaccumulation of Trace Elements in Edible Portions.

Element	Green beans			Carrot			Beets			Lettuce		
	AN	BI	NO	AN	BI	NO	AN	BI	NO	AN	BI	NO
Al	0.001	0.001	0.002	0.004	0.003	0.003	0.004	0.005	0.006	0.052	0.045	0.048
Ba	0.092	0.084	0.072	0.195	0.234	0.428	0.282	0.392	0.784	0.172	0.243	0.253
B	1.481	2.067	3.833	1.915	2.611	3.967	1.492	2.000	3.050	1.785	2.644	4.100
Cd	0.078	0.074	0.067	0.532	0.678	0.556	0.320	0.291	0.300	1.320	1.096	1.200
Cr	0.200	0.038	0.100	0.111	0.113	0.083	0.044	0.038	0.033	0.411	0.438	0.600
Co	0.035	0.042	0.038	0.009	0.010	0.007	0.009	0.010	0.014	0.050	0.042	0.052
Cu	0.369	0.633	1.250	0.492	0.589	1.450	0.654	0.667	1.225	0.454	0.700	1.825

Li	**0.017**	**<0.02**	**0.006**	**0.019**	**0.015**	**0.030**	**0.129**	**0.154**	**0.209**	**0.363**	**0.403**	**0.297**
Mo	9.275	15.10	16.30	1.338	1.900	3.450	1.138	1.30	2.600	5.163	8.680	10.60
Ni	0.183	0.167	0.163	0.133	0.167	0.075	0.133	0.144	0.025	0.211	0.567	0.325
Rb	0.623	0.551	0.796	0.604	0.659	0.696	0.533	0.580	0.772	1.802	2.325	2.537
Sr	0.239	0.393	0.281	0.349	0.457	0.489	0.265	0.357	0.467	0.668	1.168	1.348
V	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.047	0.043	0.050
CV (%)	2.91	3.12	2.84	1.49	1.57	1.73	1.31	1.40	1.52	1.62	1.83	1.79

Relationship Summary: 2-D PCA Biplot

- Frequency of compost application
- Metabolites
- Soil elements

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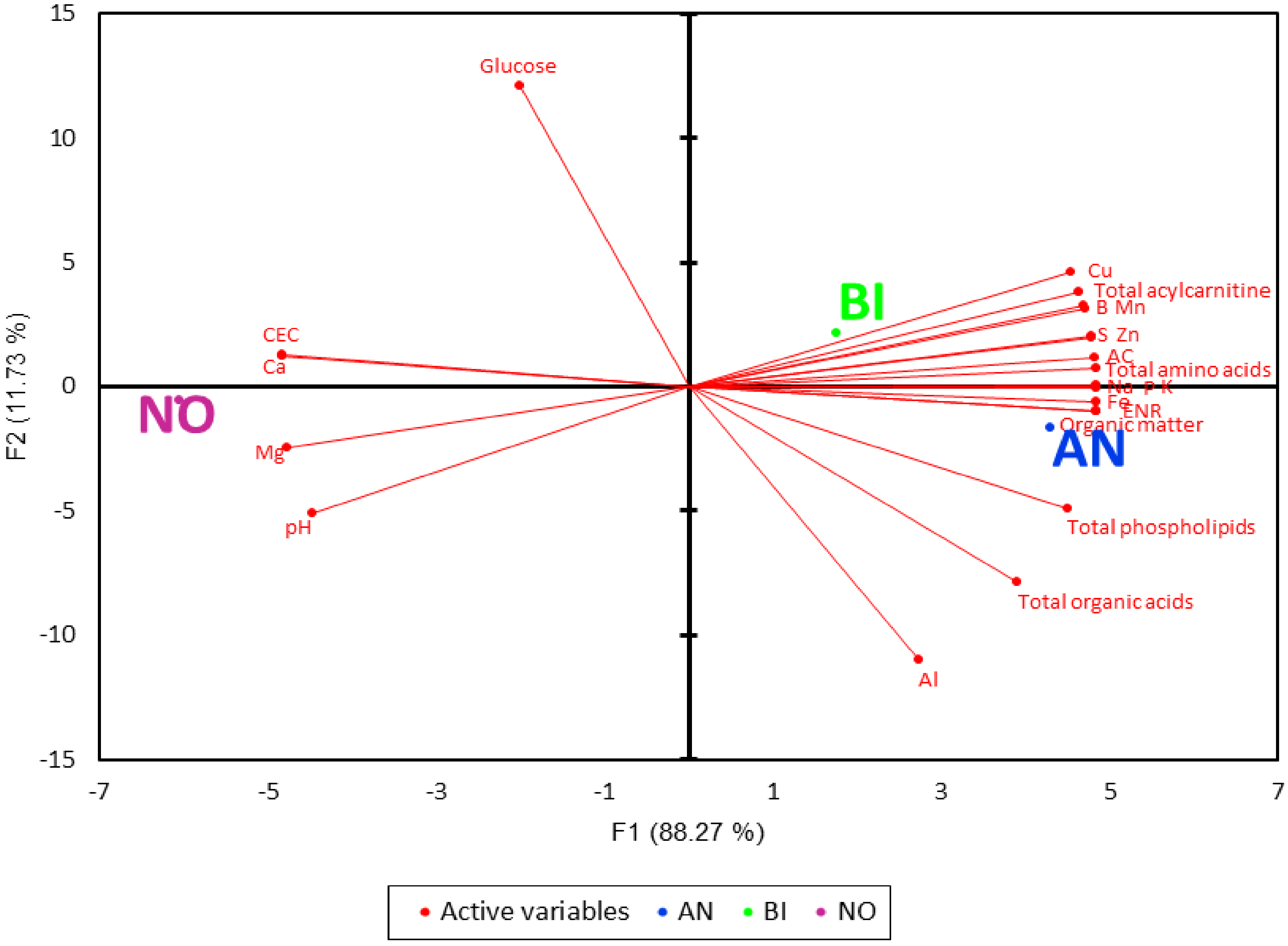
Figure 14. 2-D PCA Biplot (axes F1 and F2: 100.00 %)



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GENERAL CONCLUSION

- The findings have proven the efficacy of MSW compost in improving soil natural fertility, increasing food production and enhancing food nutrients density for healthy living
- Frequent application of MSW compost tremendously improved soil physical, chemical and microbiological properties
- The variations in microbiomes due to MSW compost application were 45% for bacteria and 11% for fungi

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CONCLUSION contd.

- Overall, the trend in changes in soil quality parameters with reference to Year 1 was annual > biennial > no compost treatment, which correlated with plant growth, yield and quality indices
- Biofortification of our food can be achieved using MSW compost
- MSW compost application offers cheaper and environmentally sustainable means of improving nutrient density and functional property of food to improve human health and wellbeing

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PUBLICATIONS

1) Impact of long-term frequent application of MSW compost on soil properties and plant productivity

2) Metabolic profiles of vegetables as influenced by frequency of application of municipal solid waste compost

3) Bioaccumulation of trace elements in field soil and edible portions of vegetables after five-year application of MSW compost

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