Physiological and biochemical effects of nano, bulk, and ionic copper in kidney bean (*Phaseolus vulgaris*) plants treated with kinetin

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Dr. Jorge Gardea's Research Group

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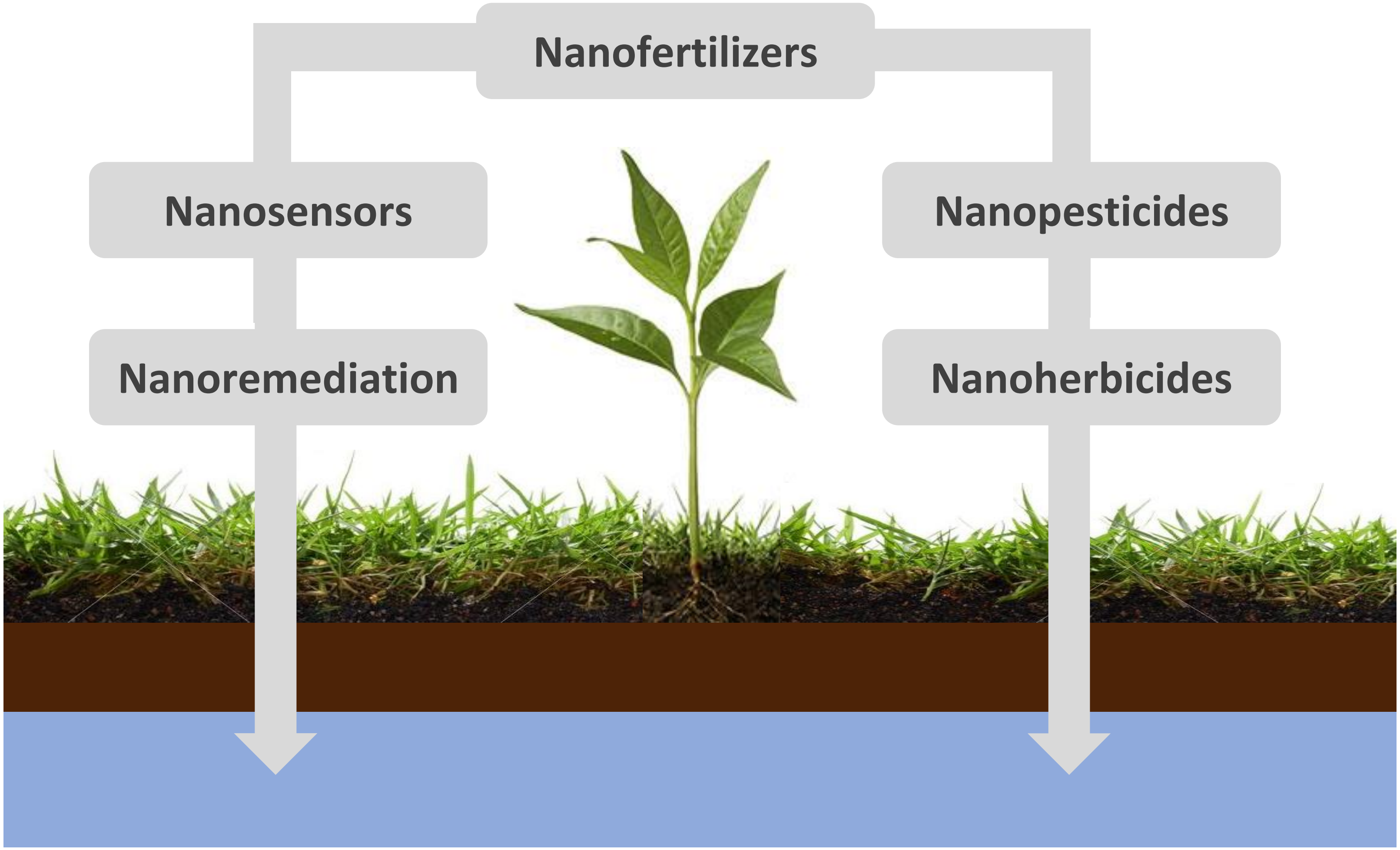
Sustainable Nanotechnology Organization
Research | Education | Responsibility

OVERVIEW

1. Background
2. Methodology
3. Results
4. Conclusions

BACKGROUND

NANOTECHNOLOGY IN AGRICULTURE



In 2016:

Prasad et al., 2017

COPPER

Essential trace mineral

Imbalance can result in toxicity or deficiency

Antimicrobial properties

29

Cu

63.546

Copper

PLANT GROWTH REGULATORS

Naturally and synthetically derived

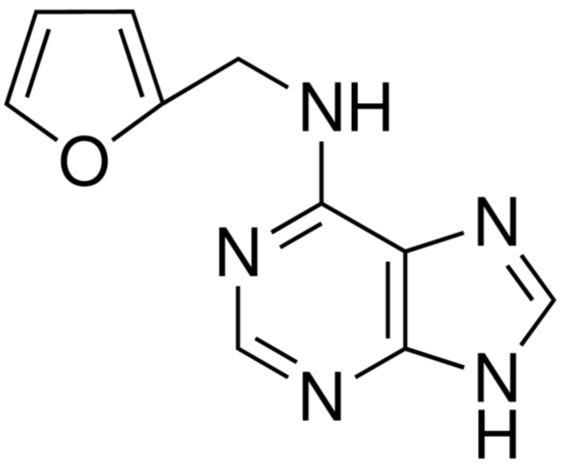
Govern developmental processes within plants

Bio-based fertilizer alternative

Stimulates cell division and enlargement

Delays senescence and acts as anti-stress agent

Phytoextraction potential



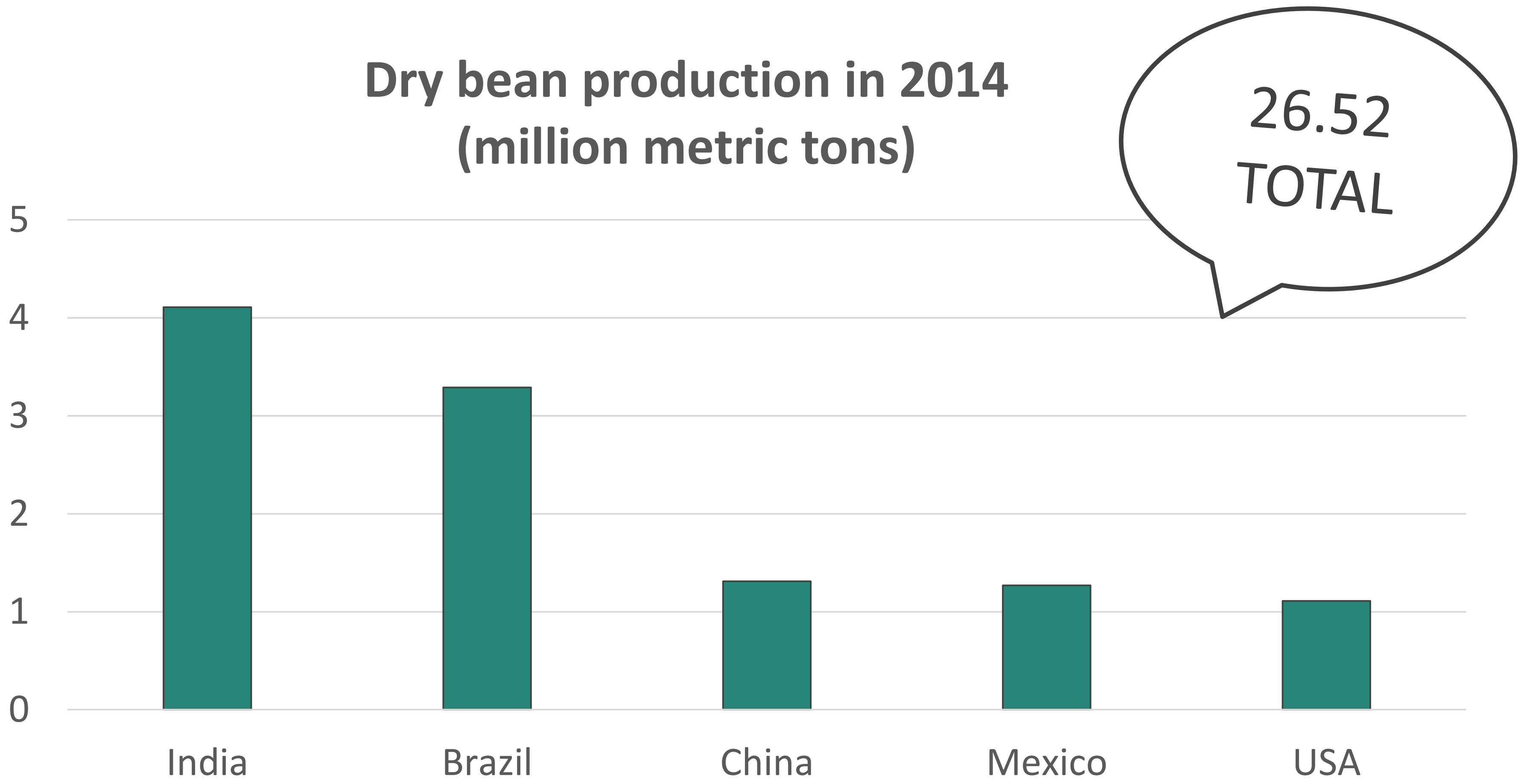
KIDNEY BEAN

Nutrient-rich and affordable

Universal staple food

Serving Size 130 g		
Servings Per Container 2		
Amount Per Serving		
Calories 110	Calories from Fat 0	
		% **Daily Value***
Total Fat 0g		**0**%
Saturated Fat 0g		**0**%
Trans Fat 0g		
Cholesterol 0mg		**0**%
Sodium 130mg		**5**%
Total Carbohydrate 19g		**6**%
Dietary Fiber 8g		**32**%
Sugars 1g		
Protein 8g		
Vitamin A 0%	• Vitamin C 2%	
Calcium 15%	• Iron 15%	

Livestrong.com



FAOSTAT, 2014

LITERATURE REVIEW

1	Humic acid increased ionic Cu content of nano Cu suspension (Musante et al., 2012)
2	Nano Cu influenced nutrient uptake and detoxification mechanisms in cucumber plants (Zhao et al., 2016)
3	Cu-based NPs decreased elemental accumulation of phosphorus in cilantro (Zuverza et al., 2015)
4	KN increased growth characters and chemical constituents in black cumin (Ahmed et al., 2017)
5	KN improved quality, yield and nutrient uptake of rice seedlings (Nazir et al., 2016)

RESEARCH GOALS

Examine the effects of different Cu compounds and KN on kidney bean plant physiology and biochemistry

- ✓ Determine the elemental uptake in plant tissues
- ✓ Analyze metabolic changes
- ✓ Evaluate seed macromolecular composition

METHODOLOGY

EXPERIMENTAL DESIGN

Factors

Nano copper – *n*Cu

Bulk copper – *b*Cu

Copper chloride – $CuCl_2$

Kinetin – KN

Statistics

One-way ANOVA

Multi-way ANOVA

KN (µM) \ Cu (mg/kg)	0	50	100
0	3	3	3
10	3	3	3
100	3	3	3

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EXPERIMENTAL PROCEDURE

Day(s) 0 1

Suspension preparation

Soil amendment

Seeds planting

Germination

Hormone application

Plant growth

4 - 6 15 16+

EXPERIMENTAL PROCEDURE

Plant growth

Day 55

Harvesting

Day 90

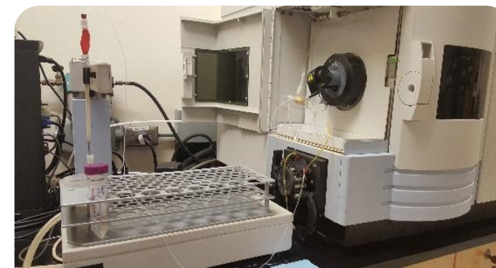
Harvesting

QUANTITATIVE ANALYSIS

UV/vis

Kjeldahl

Colorimetric

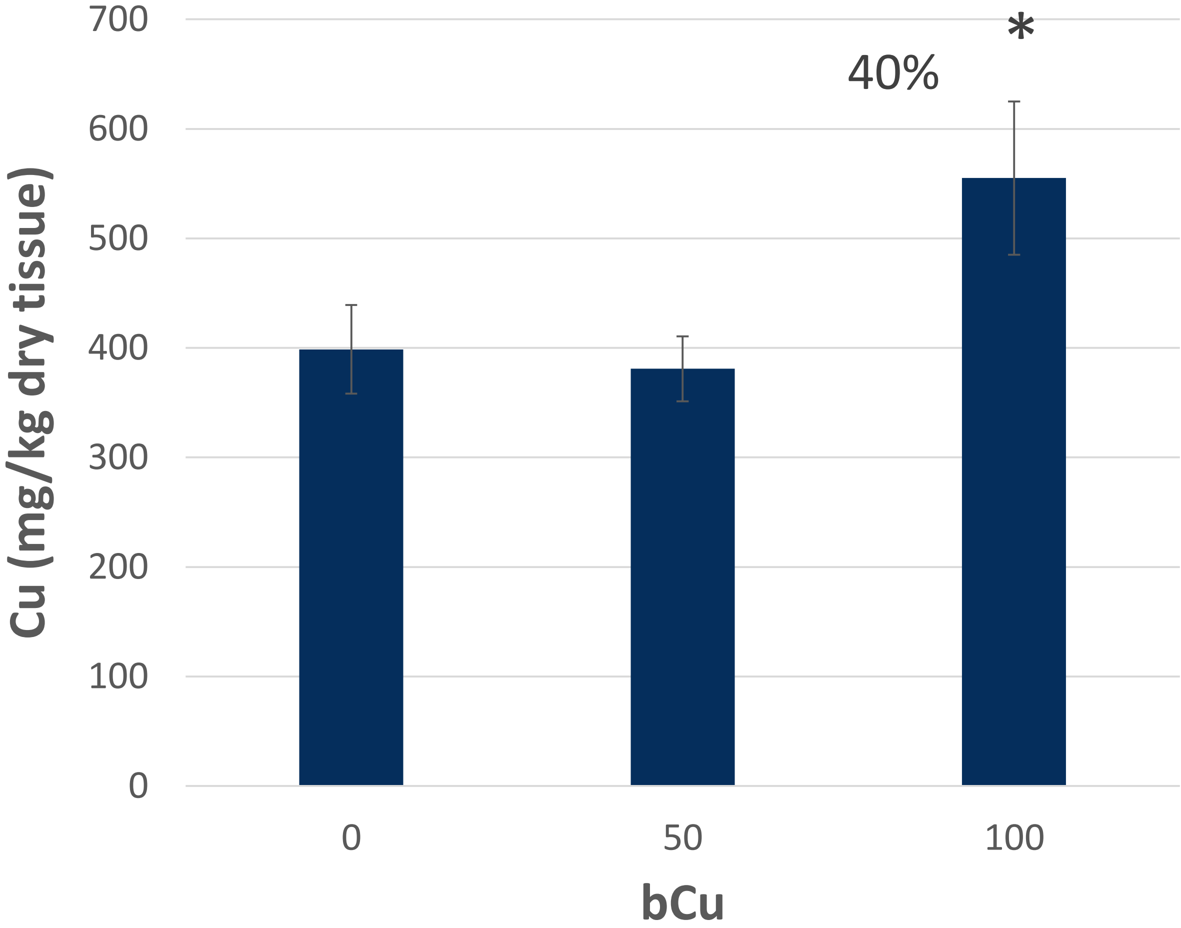


ICP-OES

RESULTS

COPPER CONCENTRATION

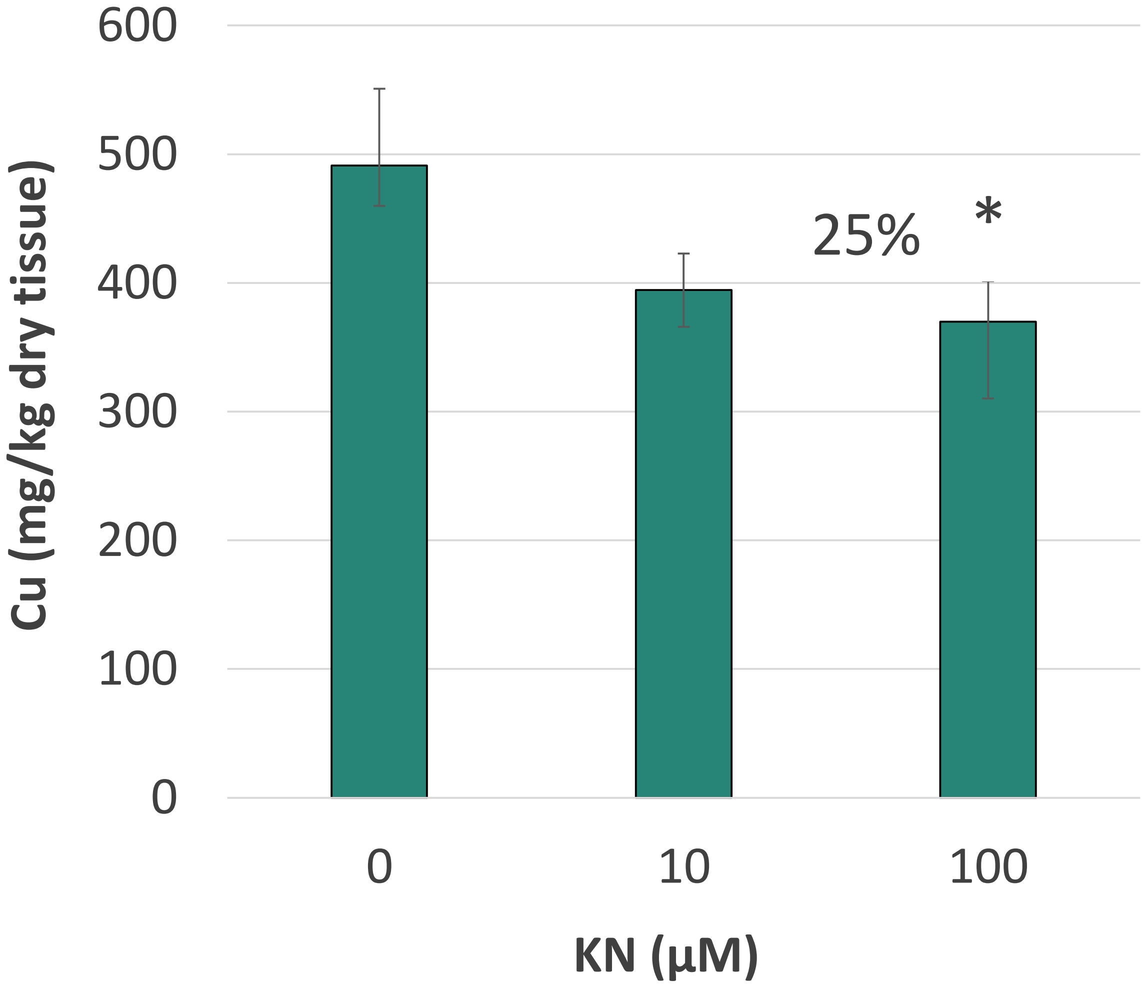
Enlarged *b*Cu particles could have adhered to root tissues



Apodaca et al., 2017

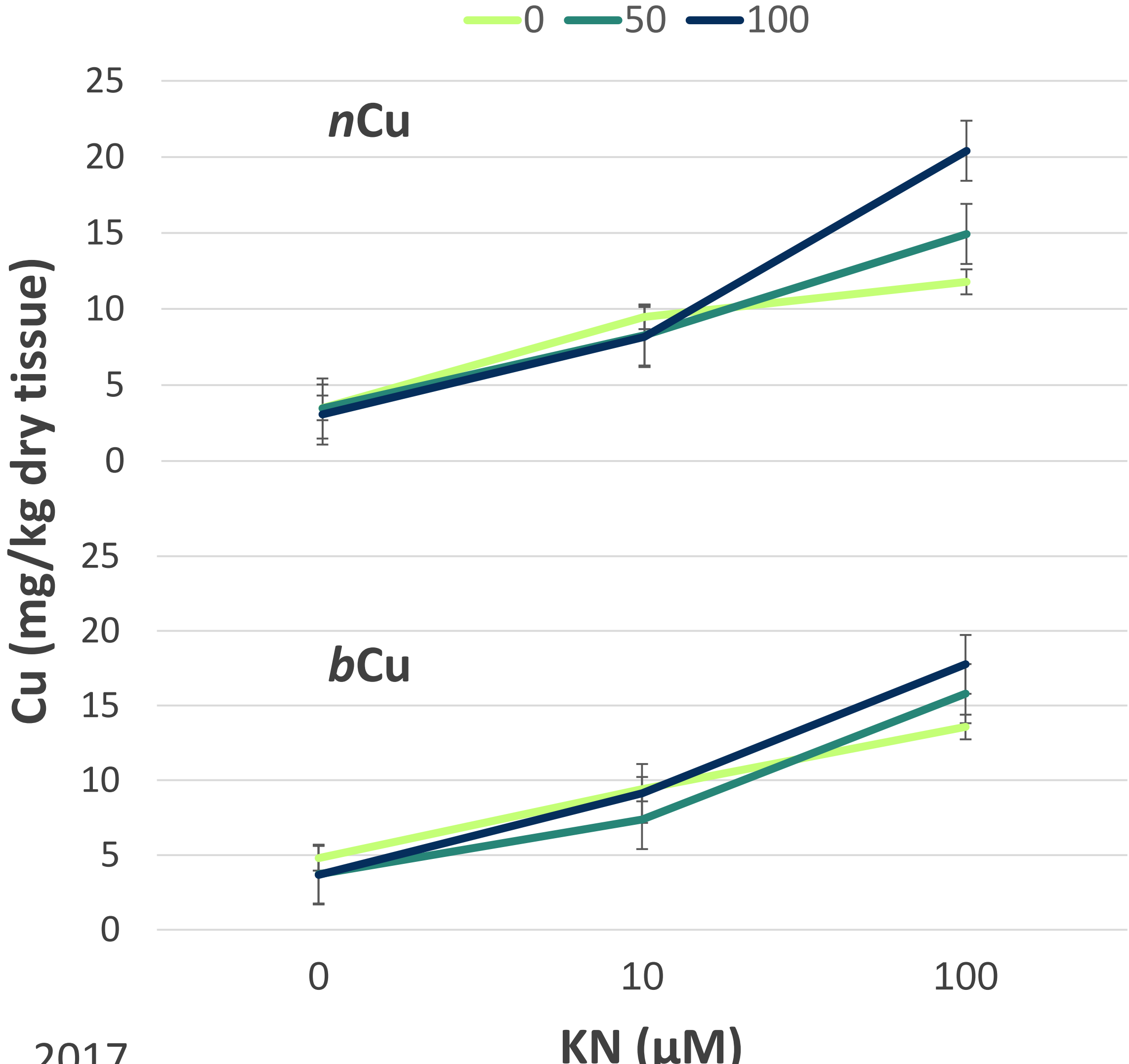
COPPER CONCENTRATION

Interference of KN with root growth system could have lowered the amount of cells available for accumulation



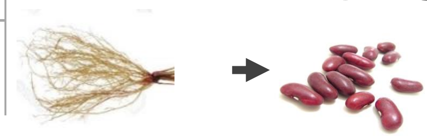
Werner et al., 2012; Apodaca et al., 2017

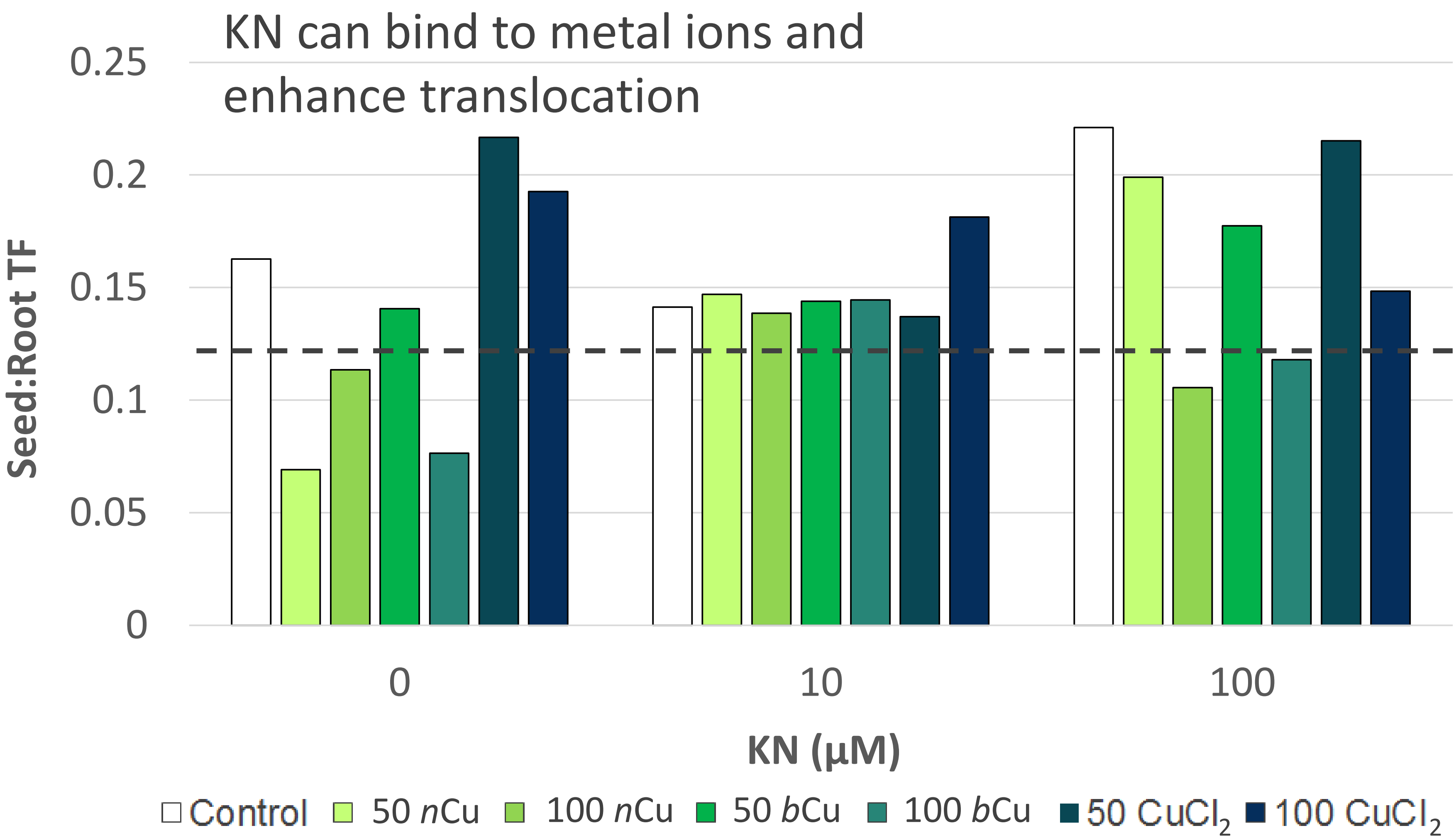
Negative surface charge of *n*Cu and *b*Cu could have preferentially bound to the N of the KN molecule



Novotná et al., 2012; Apodaca et al., 2017

TRANSLOCATION FACTOR





Olsen et al., 1999; Apodaca et al., 2017

NUTRITIONAL ELEMENTS

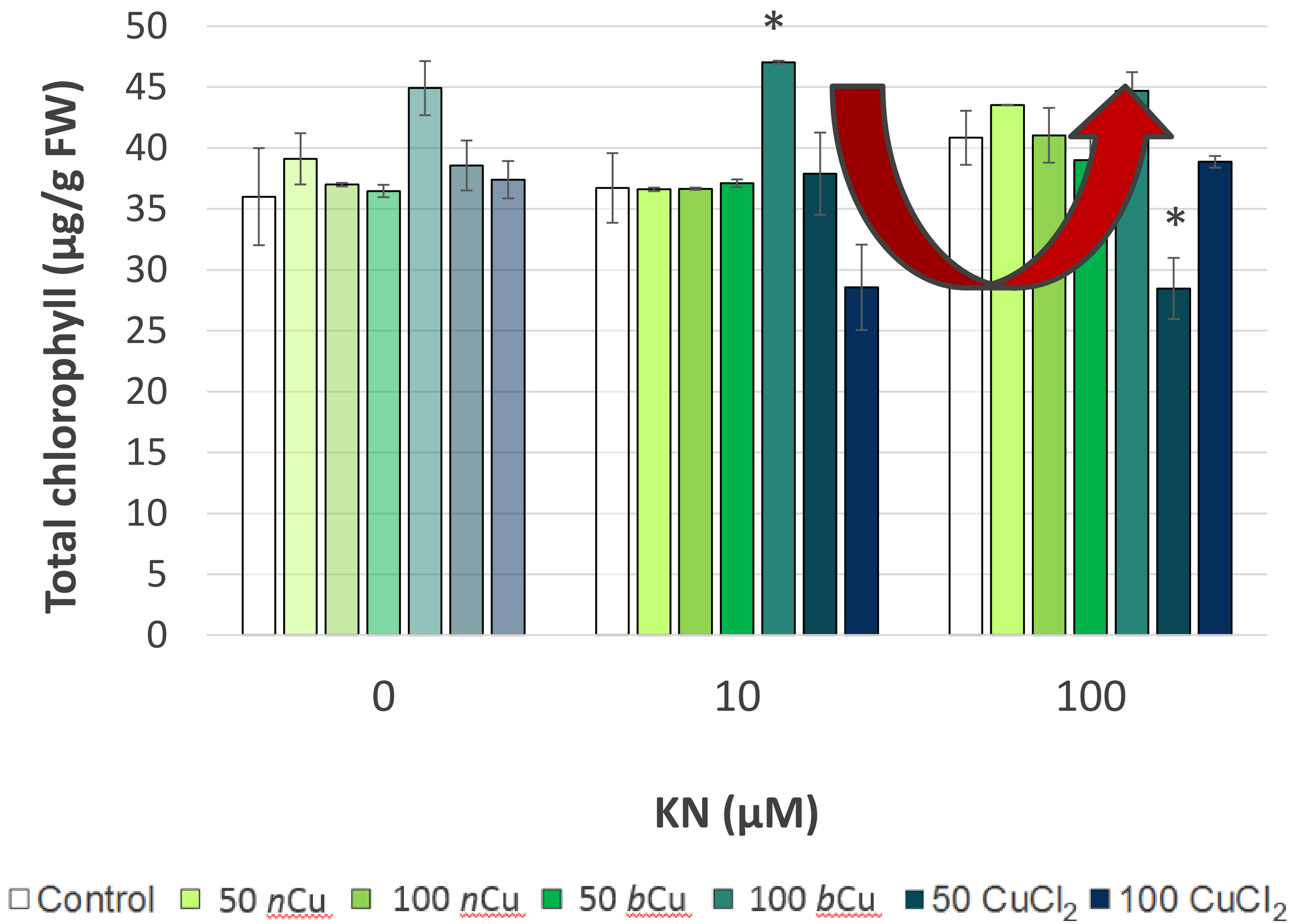
KN (µM)	Trmt (mg/kg)	Mg	S	Fe	Mn
0	50 $CuCl_2$		↑ 19%	30%	
	100 *n*Cu			↓	
	100 *b*Cu				↑
10	50 *n*Cu	↓			
	50 *b*Cu	↓			↑ ≥ 31%
	50 $CuCl_2$	↓ ≤ 12%			
	100 *n*Cu	↓			
	100 *b*Cu	↓			↑
100	50 *b*Cu				↑

Apodaca et al., 2017 (*in progress*)

CHLOROPHYLL CONTENT

Mn influences chlorophyllase activity

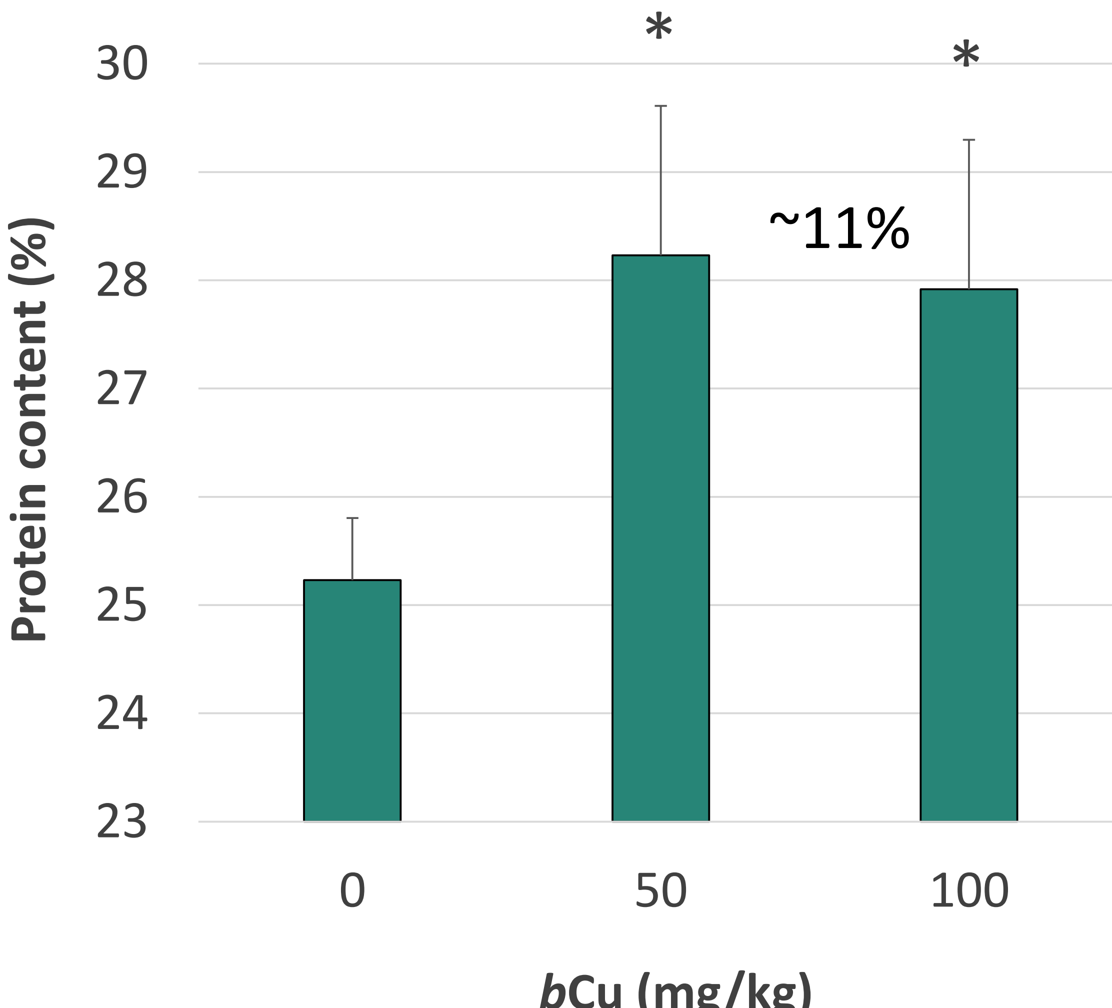
$CuCl_2$ could have inhibited protein import into chloroplasts



Seedorf et al., 1995; Cook et al., 1997; Apodaca et al., 2017 (*in progress*)

PROTEIN CONTENT

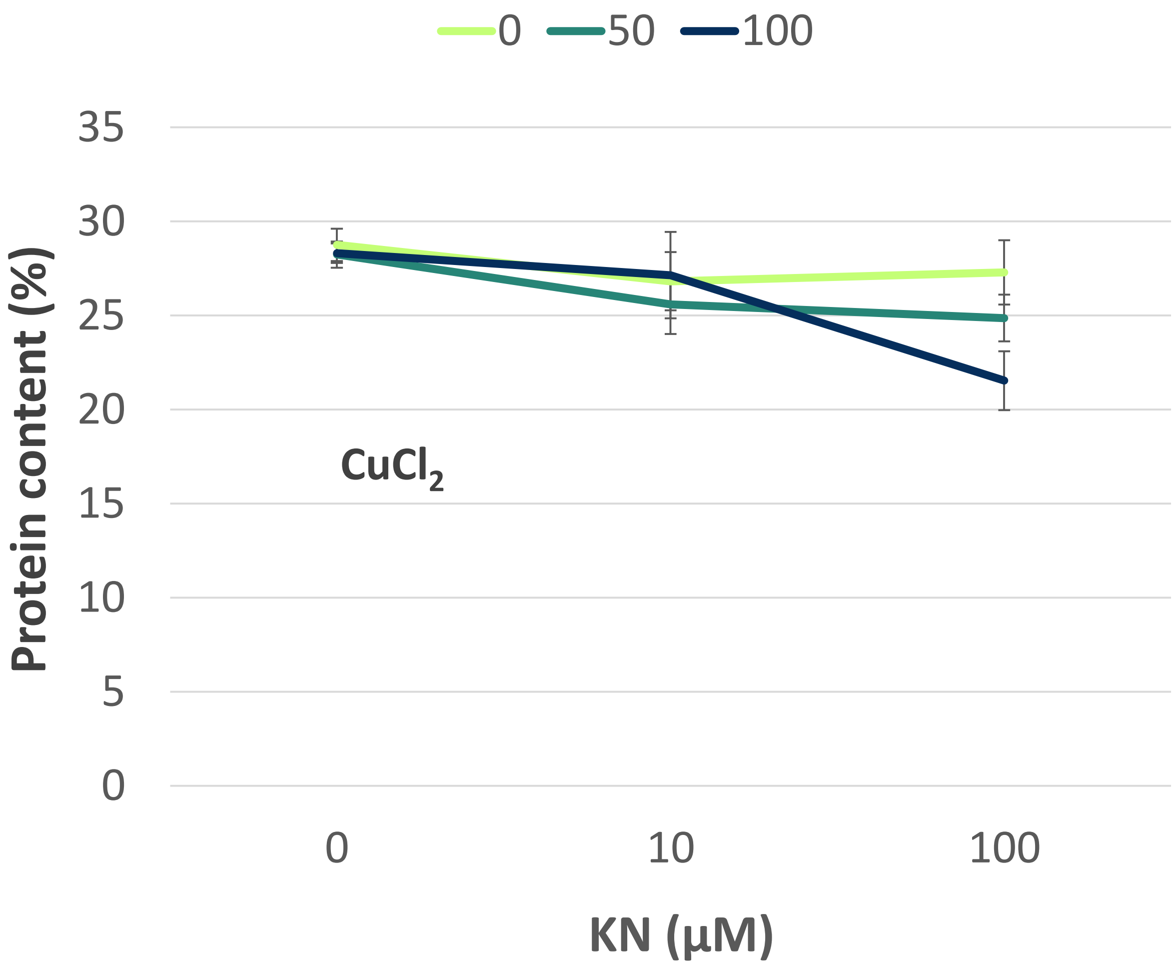
The slow release of Cu ions could have been beneficial



Singh et al., 2014; Apodaca et al., 2017 (*in progress*)

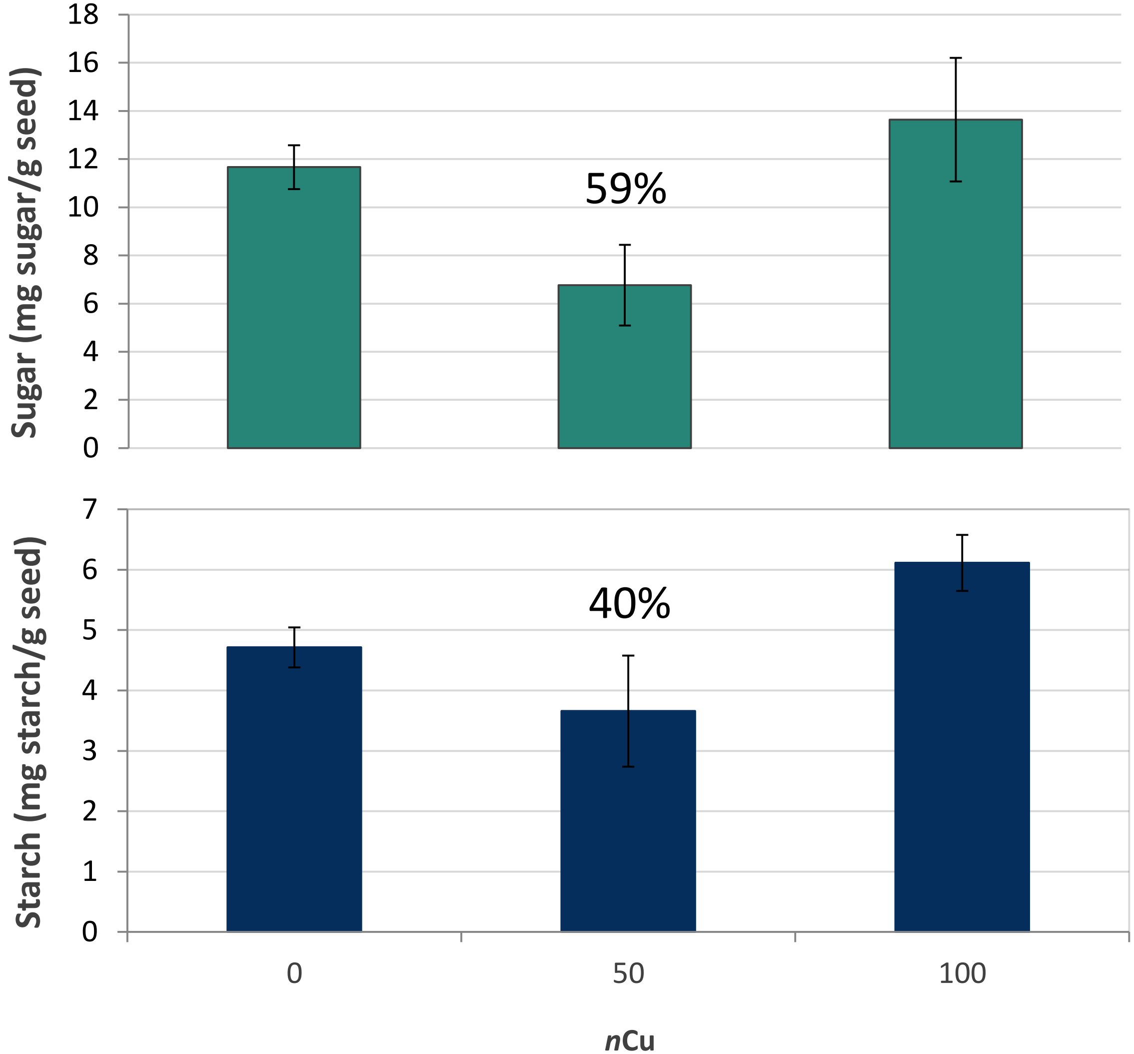
PROTEIN CONTENT

Toxicity due to immediate release of Cu ions



SUGAR & STARCH CONTENT

Further study will be done to fully understand this mechanism



CONCLUSION

SUMMARY & CONCLUSIONS

- ✓ Translocation of Cu was enhanced by KN
- ✓ As a main factor, *b*Cu increased the elemental uptake and accumulation of Mn
- ✓ The combination of *n*Cu + KN is neither toxic nor beneficial
- ✓ Protein was decreased by the interaction between $CuCl_2$ + KN

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thank
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