YIELD RESPONSE OF MAIZE TO P AND K FERTILIZATION INCREASED BY CO-APPLICATION WITH HUMIC ACID

Crop Physiology

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OBJECTIVE: ***Determine if the co-application of granular humic acid improves the yield response of maize to P and K fertilization.***

INTRODUCTION:

Phosphorus (P) and potassium (K) are two of the three mineral nutrients required by maize (*Zea mays* L.) in the greatest quantities, leading to fertilizer applications of these nutrients to meet yield demand. However, these fertilizer sources are in limited supply, incentivizing efforts to increase their efficiency.

Granular humic acids (HA), carbon-based products mined from lignite/leonardite, are specialty products proposed to influence nutrient availability and impact maize yield. However, it is unknown if granular HAs can increase yield when applied alone (furthering inherent soil fertility) or if a synergistic benefit can be achieved by co-applying humic acid with P and K fertility (improving fertilizer use efficiency).

MATERIALS AND METHODS:

Location: Champaign, Illinois on a Mollisol soil (Organic matter, 3.7%; CEC, 17.6; pH, 7.0) with conventional tillage.

Design: Experimental units each year were plots four rows wide, 0.76 m row spacing, and 11.4 m long, arranged in a randomized complete block experimental design with six replications.

Management: Plots were established using the maize hybrid DKC59-81 at a population of 89,000 plants ha^{-1}. All plots received NBPT treated urea (46-0-0) at 200 kg nitrogen ha^{-1} prior to planting and incorporated.

Parameters Evaluated: The two inner rows were harvested for grain yield, kernel number, and kernel weight and expressed at 0% moisture.

2020 Treatments: Phosphorus and potassium were broadcast-applied at plant growth stage V2 as monoammonium phosphate (MAP; 11-52-0) and muriate of potash (MOP; 0-0-60), respectively. Humic acid (Novihume; 78% OM, 21% Bentonie clay), sourced from lignite, was applied with or without P + K (Table 1).

Table 1. Humic acid (HA), phosphorus (P), and potassium (K) amounts applied as treatments to maize in 2020.

Treatment	Humic Acid	P	K
	kg ha^{-1}	kg P_2O_5 ha^{-1}	kg K_2O ha^{-1}
Untreated Control	0	0	0
Humic Acid (HA)	168	0	0
P + K	0	90	67
HA + P + K	168	90	67

2021 Treatments: A reduced rate of phosphorus was applied as a combination of MicroEssentials-S10 (12-40-0-10S) and SusTerra (14-24-0-10S) at a ratio of 8:5, respectively. Potassium was applied as MOP. Humic acid was applied at a low (84 kg ha^{-1}) or high (168 kg ha^{-1}) rate (Table 2). Treatments were broadcast applied prior to planting and incorporated.

Table 2. Humic acid (HA), phosphorus (P), and potassium (K) amounts applied as treatments to maize in 2021.

Treatment	Humic Acid	P	K
	kg ha^{-1}	kg P_2O_5 ha^{-1}	kg K_2O ha^{-1}
Untreated Control	0	0	0
HA Low Rate	84	0	0
HA High Rate	168	0	0
HA Low Rate + P	84	72	0
HA High Rate + P	168	72	0
HA Low Rate + P + K	84	72	67
HA High Rate + P + K	168	72	67

2020 RESULTS AND DISCUSSION:

Applying humic acid with P + K fertility resulted in a positive synergistic effect on maize grain yield.

- Broadcast applications of HA + P + K increased maize grain yield by 1.1 mg ha^{-1} compared to the untreated control. In contrast, applying HA or P + K alone had no effect on grain yield, implying that there is a positive synergistic benefit to co-applying humic acid with P + K fertility (Table 3).
- Although not statistically significant, plants treated with HA + P + K tended to produce heavier kernels and more kernels than the other treatments. These results infer the addition of humic acid with P + K fertility improved availability of fertilizer nutrients and subsequent plant growth and productivity (Table 3).

These findings influenced the design of the 2021 trial in which we sought to answer if the same synergistic effect could be achieved with different rates of humic acid and when combined with only P.

2021 RESULTS AND DISCUSSION:

Maize yield increases resulting from co-applications of humic acid with P + K are based on the presence of K.

- On average, HA when co-applied with P + K increased maize grain yields by 0.8 mg ha^{-1} compared to the untreated control (Table 4). Conversely, when applied without P + K fertility or with P alone, HA applications tended to decrease the average yields at both rates by 0.4 and 0.7 Mg ha^{-1}, respectively, compared to the untreated control. These results suggest that there may be an interaction between HA and K fertility on yield, although a treatment with only P + K fertility is needed for confirmation.
- Similar to 2020, kernel number tended to increase in plants which received the high rate of HA with P + K fertility. However, when averaged across both rates of HA with P + K fertility, kernel number did not increase, which could be a result of the different timings of broadcast applications of treatments (Table 5). Kernel weight, when averaged across both low and high rates of HA and co-applied with P + K fertility, was 16 mg $kernel^{-1}$ higher than the untreated control, also similar to the trend observed in 2020 (Table 6).

Although the treatments varied slightly across both years, there was a consistent synergistic benefit of applying HA with P + K fertility which resulted in increased maize grain yield.

Table 3. Grain yield and yield components as affected by different fertilizer and HA treatments for maize grown at Champaign, IL in 2020.

Treatment	Grain Yield	Kernel Number	Kernel Weight
	Mg ha^{-1}	kernels m^{-2}	mg $kernel^{-1}$
Untreated Control	13.6	5115	271
Humic Acid	13.7	5200	268
P + K	13.8	5179	272
HA + P + K	14.7	5460	274
LSD(.1)	0.65	NS	NS

Table 4. Grain yield as affected by different fertilizer and HA treatments for maize grown at Champaign, IL in 2021.

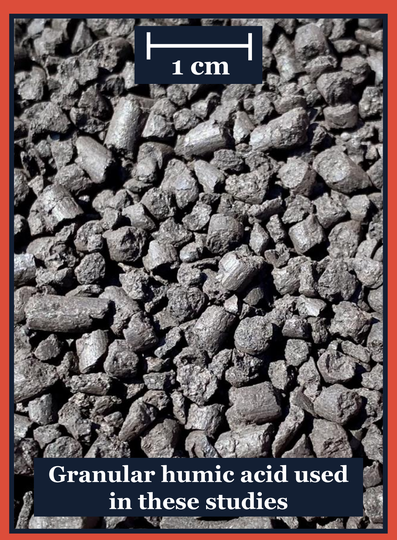
Treatment	Grain Yield		
	Humic Acid Rate		Average
	Low	High	
	Mg ha^{-1}		
Untreated Control	13.4		-
Humic Acid	13	13	**13**
P	12.9	12.4	**12.7**
P + K	14	14.4	**14.2**
LSD(.1)	NS		0.4

Table 5. Kernel number as affected by different fertilizer and HA treatments for maize grown at Champaign, IL in 2021.

Treatment	Kernel Number		
	Humic Acid Rate		Average
	Low	High	
	kernel m^{-2}		
Untreated Control	5198		-
Humic Acid	4920	5110	**5015**
P	4957	4677	**4817**
P + K	5137	5214	**5175**
LSD(.1)	NS		244

Table 6. Kernel weight as affected by different fertilizer and HA treatments for maize grown at Champaign, IL in 2021.

Treatment	Kernel Weight		
	Humic Acid Rate		Average
	Low	High	
	mg $kernel^{-1}$		
Untreated Control	257		-
Humic Acid	264	255	**259**
P	262	265	**263**
P + K	271	275	**273**
LSD(.1)	NS		9



Granular humic acid used in these studies

CONCLUSIONS:

- **Applying humic acid with P + K fertility resulted in a positive synergistic effect on maize grain yield.**
- **Humic acid applied without P + K had no effect on maize grain yield.**
- **Applying humic acid with P + K fertility can improve fertilizer use efficiency and productivity of maize, primarily by the addition of K.**