Report

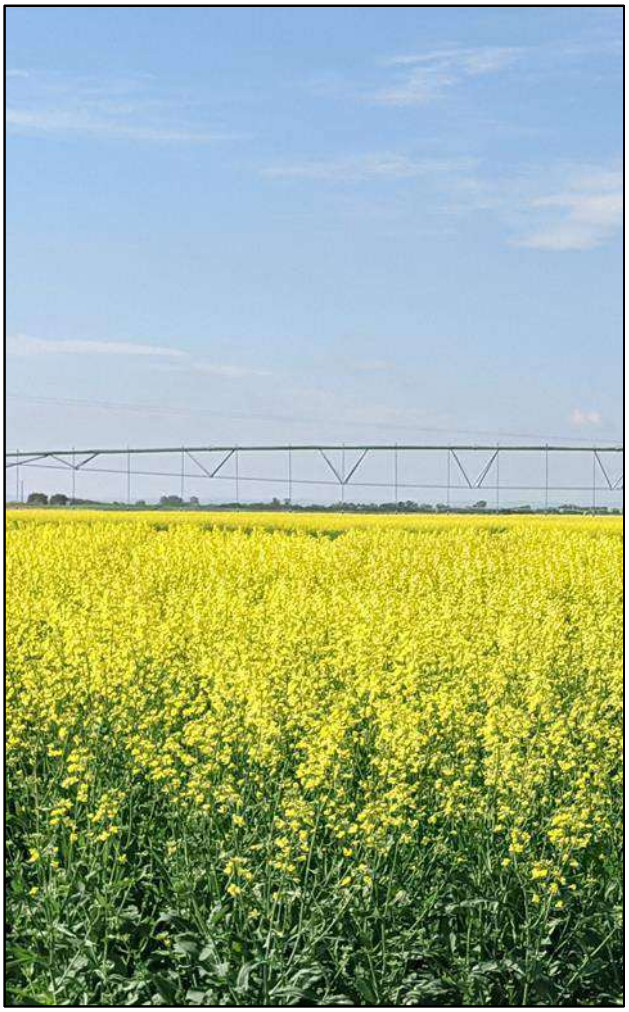
For The

Saskatchewan Canola Development Commission

and

Saskatchewan Flax Development Commission

Project Title: Response of Canola and Flax to Humic acid coated P fertilizer (MAP) rates



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1. **Project Title:** Response of Canola and Flax to Humic acid coated P fertilizer (MAP) rates.

2. **Project Number:**

3. **Producer Group Sponsoring the Project:** Irrigation Crop Diversification Corp. (ICDC), Indian Head Research Foundation (IHARF), Conservation Learning Center (CLC) and East Central Research Foundation (ECRF)

4. **Project Location(s):** Outlook (ICDC), Indian Head (IHARF), Prince Albert (CLC) and Yorkton (ECRF)

5. **Project start and end dates (month & year):** April 2023 – March 2024

6. **Project contact person & contact details:**

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7. **Project objectives:**

This study aimed to demonstrate if humic acid-coated MAP (Monoammonium phosphate) fertilizer can promote phosphorus absorption by plants and enhance fertilizer utilization rates.

8. **Project Rationale:**

Humic acid fertilizers are widely used in agricultural production, soil remediation, and environmental protection. Humic acid is a readily available and low-cost material that, when combined with various inorganic fertilizers, has been shown to optimize soil structure, stimulate and increase germination percentage, promote plant establishment, and improve fertilizer utilization, thereby increasing yield and income 1,2. Humic acid, an organic substance formed through the decomposition and transformation of animal and plant remains by microorganisms, undergoes a series of geochemical processes.

The effect of humic acid as a nutrient enhancer on macronutrients N, P and K has already been explored in Europe and Asia on various crops (2,3,4). Compared with the same amount of ordinary fertilizer, humic acid-coated fertilizer showed a high capacity for stabilizing urease. It increased the natural circulation reduction ability of the nitrogen element by about 1/3, increased the phosphate activities in the soil and hence reducing the fixed loss of available phosphorus by nearly half, and decreased the loss rate of available potassium by 1/3 (1). In the past few years, humic acid has gained much attention as fertilizer companies promote this product as a nutrient enhancer in seed placed and foliar fertilizers. Research on humic acid utilization in Canadian agriculture is limited; this is a perfect opportunity to explore its benefits. Canola is known to respond well to P applications in low P soils but is also relatively sensitive to seed placement and, as such, is an excellent test crop for this project.

Both SaskCanola and Saskatchewan Flax Development Commissions have expressed interest in conducting studies on humic acid fertilizer. This attention originated from their producer boards and members and was suggested to Agri-ARM as a potential ADOPT demonstration. Despite claims from existing literature and private industry/retailers about the benefits of humic acid for crops and fertilizer utilization, there is a lack of research trials in Saskatchewan to substantiate these claims.

It has been asserted that humic acid reduces the fixation of available phosphorus in the soil, activates the insoluble phosphorus, and increases the soluble phosphorus in the soil or directly reacts with the phosphate fertilizer to promote phosphorus absorption by plants. Since Saskatchewan soils have very low available P levels and given the high cost of fertilizers in the past few years, using humic acid blended with various inorganic P fertilizers may help improve fertilizer P recovery and increase economic returns for Saskatchewan growers.

1. Yanan Li (2020) Research Progress of Humic Acid Fertilizer on the Soil. J. Phys.: Conf. Ser. 1549 022004

2. Li Y, Fang F, Wei J et al. (2019) Humic Acid Fertilizer Improved Soil Properties and Soil Microbial Diversity of Continuous Cropping Peanut: A Three-Year Experiment. Sci Rep 9, 12014.

3. Delfine S, Tognetti R, Desiderio E and Alvino A (2005). Effect of foliar application of N and humic acids on growth and yield of durum wheat. Agron. Sustain. Dev. 25 183–191.

4. Ahmad T, Khan R and Khattak T N (2018) Effect of humic acid and fulvic acid based liquid and foliar fertilizers on the yield of wheat crop, Journal of Plant Nutrition, 41:19, 2438-2445.

9. Methodology:

Small plot trials were established at Indian Head (IHARF), Yorkton (ECRF), Prince Albert (CLC), and Outlook (ICDC). Five treatments (Table 1) were implemented using a Randomized Complete Block Design, with four replications for each crop. All P fertilizer was placed in the seed row, and nitrogen, in the form of urea (46-0-0), was uniformly side-banded across all treatments. Response of Canola and flax was evaluated in separate and individual trials.

Data collection encompassed various aspects, including soil testing for residual soil nutrients and qualities in the spring, emergence count, early-season biomass, Tissue P, maturity dates, and yield estimation at harvest.

For plant biomass and P tissue uptake, all above-ground plant material from 2 x 0.5 m sections of crop rows per plot was harvested, dried, and weighed to determine early-season biomass yields. Canola samples were collected between bud formation and early bolting, while flax samples were taken from early bloom to the start of boll initiation. Following the recording of wet and dry weights, individual plot samples were ground and mixed equally to create bulked treatment samples, which were then submitted to AgVise for determining percent P.

Table 1. Treatment plan for both canola and flax field trials

Treatment	Canola/Flax
1.	control
2.	1X (25 kg/ha P2o5) MAP
3.	1X (25 kg/ha P2o5) MAP treated with humic acid
4.	2X (50 kg/ha P2o5) MAP
5.	2X (50 kg/ha P2o5) MAP treated with humic acid

Results

Mean monthly temperatures and precipitation amounts for each location, along with the long-term (30-year) averages, are presented in Table 2. All locations experienced notably warmer temperatures than the average, with May and June being particularly hot. July exhibited a slight cool-down, ranging from slightly below average to approximately average, while August temperatures were around average to slightly above. Throughout the four-month period from May to August, growing season temperatures ranged from 1.4 to 1.9 °C above the average. Precipitation levels were below normal at all participating locations. Outlook recorded the lowest precipitation with only 95 mm (46% of the average); however, it is worth noting that this location is irrigated and received an additional 279 mm of irrigation water between June and August.

Table 2. Weather data from four Saskatchewan sites investigating canola seeding dates and rates in 2023.

Location	Year	May	June	July	August	Avg/Total
		--- Total Precipitation (mm) ---				
Prince Albert	2023	22.8	52.8	40.8	51.2	167.6
	2015-2022	34.1	62.0	67.6	42.9	206.6
Yorkton	2023	16.8	67.9	18	33.3	136.0
	2010-2023	51.3	80.1	78.2	62.2	271.8
Outlook[X]	2023	17.5	15.3	15.5	16.6	64.9
	1992-2023	41.5	65.3	55.8	43.9	206.5

Indian Head	2023	12.9	49.6	15.9	40.8	119.2
	1997-2021	51.7	77.4	63.8	51.2	244.1
		--- *Mean Temperature (°C)* ---				
Prince Albert	2023	14.4	18.8	16.6	17.1	16.7
	2015-2022	11.1	16.3	18.6	16.9	15.7
Yorkton	2023	13.8	19.7	16.7	17.8	17.0
	2010-2023	10.4	15.5	17.9	17.1	15.2
Outlook	2023	15.2	19.45	18.6	18.7	18.0
	1993-2023	11.25	16.1	18.85	17.9	16.0
Indian Head	2023	14.0	19.4	16.7	17.7	17.0
	1997-2021	10.8	15.8	18.2	17.4	15.6

[X]Outlook site received a total of 117 mm in June, 119 mm in July, and 43mm in August of cumulative precipitation as irrigation.

The trial was overseen with a focus on implementing best management practices across all sites. Control measures for broadleaf weeds, diseases, and insects were applied using registered pesticides as necessary, based on the judgment of each site manager. Details regarding all operational dates and agronomic information can be found in Tables 3 and 4.

Table 3. Dates of operations in Canola trial in 2023.

Operation	**Prince Albert**	**Indian Head**	**Yorkton**	**Outlook**
Pre-seed herbicide (if needed)	Roundup Transorb HC @0.67L/ha on May 12	0.67 l/ac Roundup Weathermax on May 20	none	EDGE MICROACTIV (8.5 kg/ha) on May 1
Seed trial	May 24	May 18	May 20	May 12
Seed rate	120 seeds/m^2	115 seeds/m^2	115 seeds/m2	200 seeds/m^2
Emergence counts	June 02	June 13	June 05	June 14
In-crop Herbicide	Poast Ultra @ 1.1L/ha on June 08	Liberty 150SN (1.35 l/ac) + Centurion (50 ml/ac) + 0.5% Amigo and 0.2% Valid (drift reducer) on June 9	Liberty 150SN (1.35 l/ac) on June 06 Centurion + Amigo + AMS on June 20	Liberty 150SN (1.35 l/ac) on June 5
In-crop Fungicide	none	0.280 l/ac Cotegra applied on July 5	Acapella on July 05	none
In-crop Insecticide	none	none	none	Matador 120EC (grasshopper) on May 30
Harvest Aid	Reglone Ion @2.04L/ha on Aug 29	Roundup Weathermax (0.67 l/ac) on August 2	none	Reglone Ion @2.04L/ha on Aug 26
Harvest date	Sept 08	Sept 06	Aug 30	Sept 7

Table 4. Dates of operations in Flax trial in 2023.

Operation	Prince Albert	Indian Head	Yorkton	Outlook
Pre-seed herbicide (if needed)	Roundup Transorb HC @0.67L/ha on May 12	Authority 480 (0.118 l/ac) on May 19 and Roundup Weathermax (0.67 l/ac) on May 20	none	Roundup Transorb HC @0.67L/ha on May 17
Seed trial	May 29	May 16	May 24	May 29
Seed rate	67.5 kg/ha	50 kg/ha	50 kg/ha	50 kg/ha
Emergence counts	June 02	June 06	June 05	June 12
In-crop Herbicide	none	0.405 l/ac Buctril M + 300 ml/ac IPCO Contender (Assure 2) + 1% IPCO MSO adjuvant on June 10	Curtail M on 07-Jun-23 Centurion + Amigo + AMS on June 19	Buctril m+ clethodim on June 26
In-crop Fungicide	none	Dyax (0.16 l/ac) + Agrol 90 (0.125%) applied on July 5	none	none
In-crop Insecticide	none		Dyax on 07-Jul-23	
Harvest Aid	Reglone Ion (2.04L/ha) on Sept 21	Roundup Weathermax (0.67 l/ac) on Aug 23	Reglone Ion (2.04L/ha) on Aug 31	Reglone Ion (2.04L/ha) on Oct 2
Harvest date	Oct 16	Sept 8	September 06	Oct 10

Soil test results for both canola and flax sites are presented in Table 5 below. The available phosphorus nutrient levels at IHARF, CLC, and ICDC sites were within the low range, while at ECRF sites, they ranged from medium to high. Nitrogen fertilizer application followed soil test recommendations and was adjusted for the varying phosphorus treatments. Soil pH, organic matter, and C.E.C. values exhibited a broad range but were deemed typical for their respective locations.

Table 5. Selected soil test analyses result at IHARF (Indian Head), ICDC (Outlook), CLC (Prince Albert), and SERF (Yorkton) in 2023. Unless otherwise indicated, all measurements represent the 0-6 inches soil profile.

Parameter	CLC	IHARF	ECRF	ICDC
Canola site				
pH	6.0	7.7	6.5	7.9
Organic Matter (%)	5.7	5.9	6.3	2.6
CEC (meq)	-	41.5	21.4	22.2
NO_3-N (kg/ha) [a]	40.3	19.1	31.6	11.2
Olsen-P (ppm)	5.0	7.0	15.0	5.0
K (ppm)	253.0	650.0	385.0	277.0
kg S/ha (kg/ha) [a]	40.4	62.7	44.8	132.6
Flax site				
pH	6.1	8.0	6.5	7.9
Organic Matter (%)	6.6	5.1	6.3	3.1

CEC (meq)	-	45.9	21.4	17.9
NO3-N (kg/ha) [a]	58.2	14.5	31.6	10.0
Olsen-P (ppm)	4.0	4.0	15.0	5.0
K (ppm)	244	466	385.0	393.0
kg S/ha (kg/ha) [a]	62.7	53.7	44.8	56.0

[a]0-12"

Results

Canola response (Table 6-9)

Plant density:

Significant impacts on canola emergence were observed in five tested treatments at IHARF, CLC, and ECRF, while the effect was nonsignificant at ICDC. IHARF control plots exhibited superior plant density compared to MAP-applied plots. No variance in plant densities was observed between humic acid-treated MAP and fertilizer rates (1X vs. 2X). At ECRF, a notable difference between 1X and 2X rates was evident, with the 1X rate displaying a higher plant count.

Dry Matter:

Irrigated sites (ICDC) consistently demonstrated higher dry matter yield than dryland sites due to the impact of drier conditions across all locations. Dry matter remained unaffected among the five treatments tested at ICDC, IHARF, and CLC, except at ECRF, where a positive response to the treatment was noted. However, the actual difference in dry matter between treatments at ECRF was negligible. Control plots exhibited the lowest dry matter yield, with an increase observed with MAP rates, though the difference between MAP and humic acid-treated MAP was not statistically significant.

Plant Maturity:

Days to maturity were unaffected by MAP treatments at IHARF, CLC, and ICDC, with the exception of ECRF, where control plots matured a day earlier than MAP-applied plots.

Grain Yield:

The overall yield fell below the average yield potential at all sites. Similar to dry matter, grain yield remained unaffected by the tested treatments at IHARF, CLC, and ICDC, except at ECRF, where a positive trend for MAP application was observed compared to control plots. At ECRF, yield showed no significant impact from humic acid application and rates.

Tissue P

Tissue P samples were bulked across replicates to generate a consolidated sample for each treatment, rendering statistical analysis impractical and prohibiting the derivation of conclusions from a single data point. The results for P uptake exhibited a range of 0.16 to 0.55 %, indicating a tendency towards increased Tissue P with MAP application compared to the control. Detailed results for each site can be found in Tables 6-11.

Flax response (Table 10 -14)

Plant density

The seeding rate for flax at each site is provided in Table 4. Dryer spring soil conditions influenced flax emergence at ICDC, resulting in lower plant density (mean – 285 plants/m2). Overall, plant counts exhibited no significant variation between treatments (control vs. MAP treatments, MAP vs. Humic acid MAP, 1X and 2X MAP rates) at all sites. However, at ICDC, there was a significant difference in plant densities between the control and MAP fertilizer treatments. Plant count also varied with fertilizer rates, with 1X rate treatments exhibiting superior plant densities compared to 2X (Table 12).

Dry Matter and Plant Maturity

Flax dry matter yield and maturity remained unaffected by the tested treatments at all sites. At CLC, flax maturity was impacted by untimely August rainfall and a late frost.

Grain Yield:

Flax yield was impacted by adverse conditions across all sites. Additionally, at CLC, flax plots were affected by wildlife damage (deer) due to delayed harvest, resulting in significantly lower yields. IHARF recorded a significant impact of tested treatments on flax yield, with check plots (0 P fertilizer) displaying the lowest yield and a yield increase with adding P fertilizer. Fertilizer rates (1X vs. 2X) also influenced flax yield, with higher yields observed for 2X rates. No yield advantage was observed in flax due to Humic acid treatments. ECRF and ICDC showed no significant treatment effect on flax yield.

Tissue P

Treatment samples were bulked across replicates like canola, making statistical analysis unfeasible. Tissue P varied across sites and 0.11 to 0.31 %. A general trend towards increased tissue P with MAP application compared to the control was observed at IHARF.

11. Conclusions and Recommendations

Overall, environmental conditions were adverse for canola/flax production due to widespread drought and heat stress at all trial locations. This study provided valuable insights into the applicability of humic acid MAP in our current agricultural practices. However, the bulked nature of tissue P samples impedes the ability to draw precise conclusions about whether there was an enhanced phosphorus uptake in canola and flax when utilizing humic acid. The results indicate variability in plant responses across locations and treatments, emphasizing the complexity of factors influencing crop performance. Based on one-year trials, no noticeable plant density and yield improvements were observed by treating MAP fertilizer with humic acid. Further research with a more targeted approach is recommended to comprehensively understand the potential benefits of humic acid-coated MAP fertilizer in Saskatchewan agriculture.

12. Technology transfer activities

This trial was selected as a featured stop during the Joint ICDC-AAFC and IHARF field day, where the project was presented by Derek Deredall (Nutrien, Outlook) and Chris Holzapfel (iHARF), drawing an audience of approximately 200 and 160 individuals respectively. Gursahib Singh also presented the results at the Irrigation Saskatchewan conference (around 300 participants), and the Independent Crop Advisory Network (ICAN) annual conference, with approximately 50 attendees. Additionally, ICDC recorded a video for extension purposes, which has been shared on the ICDC YouTube channel.

13. Acknowledgements

Financial support for the project was provided exclusively by the Saskatchewan Canola Development Commission (SaskCanola) and Saskatchewan Flax Development Commission (SaskFlax), greatly acknowledged by the Agri-ARM affiliates participating in the study. We also appreciate the collaboration with Derek Derdall from Nutrien Outlook for supplying the Humic acid products for all sites. Additionally, we acknowledge the diligent efforts and dedication of the ICDC technical staff and summer students, who were crucial in successfully completing this project.

Appendix

Table 6: Statistical analyses and treatment mean for canola yield, plant density, dry matter, and maturity response to MAP rates and humic acid-coated MAP at Indian Head, SK, in 2023. Means within a column followed by the same letter do not significantly differ (LSD, P ≤ 0.05).

Entry	**Plant Density**		**Dry Matter**		**Tissue P**	**Maturity**		**Seed Yield**	
	(plants/m²)		*(kg/ha)*		*(%)*	*(days)*		*(kg/ha)*	
Control (0P)	106.0	a	1356.7	a	0.43	93.5	a	2595.4	a
1X - MAP	91.7	ab	1524.8	a	0.52	93.3	a	2641.3	a
1X - MAP + HA	97.4	ab	1518.2	a	0.55	93.5	a	2629.3	a
2X - MAP	90.6	b	1379.6	a	0.54	93.5	a	2612.5	a
2X - MAP + HA	87.4	b	1355.0	a	0.55	93.8	a	2576.3	a
LSD	4.60		179.9		.	0.30		48.1	
CV%	6.9		17.8		.	0.5		2.6	
P-value	0.013		NS		.	NS		NS	
P-value (Check vs rest)	0.002		NS		.	NS		NS	
P-value (MAP vs MAP+HA)	NS		NS		.	NS		NS	
P-value (1X vs 2X Rate)	NS		NS		.	NS		NS	

MAP - Monoammonium phosphate; MAP + HA - Monoammonium phosphate coated with humic acid; Check vs rest - Control (0P) vs MAP treatments; 1X rate – 25 kg P_2O_5/ha; 2X rate - 50 kg P_2O_5/ha

Table 7: Statistical analyses and treatment mean for canola yield, plant density, dry matter, and maturity response to MAP rates and humic acid-coated MAP at Prince Albert, SK 2023. Means within a column followed by the same letter do not significantly differ (LSD, P ≤ 0.05).

Entry	**Plant Density**		**Dry Matter**		**Tissue P**	**Maturity**		**Seed Yield**	
	(plants/m²)		*(kg/ha)*		*(%)*	*(days)*		*(kg/ha)*	
Control (0P)	86.3	a	2240.3	a	0.24	88.5	a	2804.0	a
1X - MAP	84.8	a	2730.3	a	0.17	86.0	a	2737.8	a
1X - MAP + HA	80.0	a	2607.3	a	0.34	86.0	a	2549.0	a
2X - MAP	71.8	ab	2859.0	a	0.37	88.5	a	3092.5	a
2X - MAP + HA	68.5	b	2948.0	a	0.40	86.0	a	3119.3	a
LSD	5.6		267.1		.	1.1		290.1	
CV%	10.1		14.1		.	14.1		14.3	
Pr > F	0.02		NS		.	NS		NS	
Check vs rest	NS		NS			NS		NS	
MAP vs MAP+HA	NS		NS			NS		NS	
1X vs 2X Rate	NS		NS			NS		NS	

MAP - Monoammonium phosphate; MAP + HA - Monoammonium phosphate coated with humic acid; Check vs rest - Control (0P) vs MAP treatments; 1X rate – 25 kg P_2O_5/ha; 2X rate - 50 kg P_2O_5/ha

Table 8: Statistical analyses and treatment mean for canola, plant density, dry matter, and maturity response to MAP rates and humic acid-coated MAP at Yorkton, SK 2023. Means within a column followed by the same letter do not significantly differ (LSD, P ≤ 0.05).

Entry	Plant Density		Dry Matter		Tissue P	Maturity		Seed Yield	
	(plants/m²)		*(kg/ha)*		*(%)*	*(days)*		*(kg/ha)*	
Control (0P)	127.5	a	2305.0	c	0.25	87.5	c	2617.5	b
1X - MAP	125.5	a	2320.0	b	0.36	89.0	b	2856.3	a
1X - MAP + HA	122.6	ab	2322.5	ab	0.36	89.3	ab	2794.5	ab
2X - MAP	103.4	bc	2332.5	a	0.38	90.3	a	2802.3	ab
2X - MAP + HA	91.4	c	2327.5	ab	0.35	89.8	ab	2985.0	a
LSD	9.2		100.6		-	0.4		4.9	
CV%	11.4		0.3		-	0.79		5.7	
P-value	0.007		0.001		-	0.001		0.04	
P-value (Check vs rest)	NS		0.003		-	0.003		0.01	
Check	-		2305.0	b	-	87.5		2617.5	
Rest	-		2325.6	a	-	89.6		2859.5	
P-value (MAP vs MAP+HA)	NS		NS		-	NS		NS	
P-value (1X vs 2X Rate)	0.001		0.012		-	0.010		NS	
1X Rate	124.0	a	2321.3	b	-	-		-	
2X Rate	97.4	b	2330.0	a	-	-		-	

MAP - Monoammonium phosphate; MAP + HA - Monoammonium phosphate coated with humic acid; Check vs rest - Control (0P) vs MAP treatments; 1X rate – 25 kg P_2O_5/ha; 2X rate - 50 kg P_2O_5/ha

Table 9: Statistical analyses and treatment mean for Canola yield, plant density, dry matter, and maturity response to MAP rates and humic acid-coated MAP at Outlook, SK 2023. Means within a column followed by the same letter do not significantly differ (LSD, P ≤ 0.05).

Entry	Plant Density		Dry Matter		Tissue P	Maturity	Seed Yield	
	(plants/m²)		*(kg/ha)*		*(%)*	*(days)*	*(kg/ha)*	
Control (0P)	134.8	a	3070.9	a	0.17	106.0	4030.2	a
1X - MAP	141.5	a	3976.4	a	0.16	106.0	4008.2	a
1X - MAP + HA	75.3	a	3661.4	a	0.17	106.0	3710.8	a
2X - MAP	95.8	a	3759.8	a	0.17	106.0	4286.0	a
2X - MAP + HA	98.0	a	3346.5	a	0.21	106.0	3995.5	a
LSD	32.20		697.2		-	-	301.3	
CV%	21.8		17.7		-	-	10.6	
P-value	NS		NS		-	-	NS	
P-value (Check vs rest)	NS		NS		-	-	NS	
P-value (MAP vs MAP+HA)	NS		NS		-	-	NS	

P-value (1X vs 2X Rate)	NS	NS	-	-	NS

MAP - Monoammonium phosphate; MAP + HA - Monoammonium phosphate coated with humic acid; Check vs rest - Control (0P) vs MAP treatments; 1X rate – 25 kg P_2O_5/ha; 2X rate - 50 kg P_2O_5/ha

Table 10: Statistical analyses and treatment mean for flax yield, plant density, dry matter, and maturity response to MAP rates and humic acid-coated MAP at Indian Head, SK, in 2023. Means within a column followed by the same letter do not significantly differ (LSD, P ≤ 0.05).

Entry	Plant Density		Dry Matter		Tissue P	Maturity	Seed Yield	
	(plants/m²)		*(kg/ha)*		*(%)*	*(days)*	*(kg/ha)*	
Control (0P)	658.4	a	1415.7	a	0.24	92.0	1979.7	d
1X - MAP	587.5	a	1723.3	a	0.26	92.0	2090.3	cd
1X - MAP + HA	629.1	a	1613.4	a	0.28	92.0	2115.7	bc
2X - MAP	592.4	a	1555.9	a	0.29	92.3	2230.2	ab
2X - MAP + HA	591.0	a	1597.8	a	0.31	92.1	2250.8	a
LSD	36.7		195.7		-	0.20	38.6	
CV%	8.5		17.5		-	0.2	2.6	
P-value	NS		NS		-	NS	<0.001	
P-value (Check vs rest)	NS		NS		-	NS	<0.001	
P-value (MAP vs MAP+HA)	NS		NS		-	NS	NS	
P-value (1X vs 2X Rate)	NS		NS		-	0.03	<0.001	

MAP - Monoammonium phosphate; MAP + HA - Monoammonium phosphate coated with humic acid; Check vs rest - Control (0P) vs MAP treatments; 1X rate – 25 kg P_2O_5/ha; 2X rate - 50 kg P_2O_5/ha

Table 11: Statistical analyses and treatment mean for flax yield, plant density, dry matter, and maturity response to MAP rates and humic acid-coated MAP at Prince Albert, SK 2023. Means within a column followed by the same letter do not significantly differ (LSD, P ≤ 0.05).

Entry	Plant Density		Dry Matter		Tissue P	Maturity	Seed Yield	
	(plants/m²)		*(kg/ha)*		*(%)*	*(days)*	*(kg/ha)*	
Control (0P)	361.8	a	2654.0	a	0.11	115.0	168.8	b
1X - MAP	343.9	a	2970.0	a	0.11	115.0	216.7	a
1X - MAP + HA	323.5	a	2878.4	a	0.12	115.0	206.0	a
2X - MAP	355.5	a	3080.2	a	0.10	115.0	213.9	a
2X - MAP + HA	308.8	a	3056.1	a	0.12	115.0	184.1	ab
LSD	53.10		195.9		-	-	14.3	
CV%	22.1		9.5		-	-	10.2	
P-value	NS		NS		-	-	0.03	
P-value (Check vs rest)	NS		NS		-	-	NS	
P-value (MAP vs MAP+HA)	NS		NS		-	-	NS	

P-value (1X vs 2X Rate)	NS	NS	-	-	NS

MAP - Monoammonium phosphate; MAP + HA - Monoammonium phosphate coated with humic acid; Check vs rest - Control (0P) vs MAP treatments; 1X rate – 25 kg P_2O_5/ha; 2X rate - 50 kg P_2O_5/ha

Table 12: Statistical analyses and treatment mean for flax yield, plant density, dry matter, and maturity response to MAP rates and humic acid-coated MAP at Yorkton, SK 2023. Means within a column followed by the same letter do not significantly differ (LSD, P ≤ 0.05).

Entry	Plant Density		Dry Matter		Tissue P	Maturity		Seed Yield	
	(plants/m²)		*(kg/ha)*		*(%)*	*(days)*		*(kg/ha)*	
Control (0P)	514.2	a	2400.0	a	0.16	96.0	a	1948.7	a
1X - MAP	550.7	a	2375.0	a	0.18	93.5	a	2257.7	a
1X - MAP + HA	524.5	a	2385.0	a	0.18	94.5	a	2116.5	a
2X - MAP	506.4	a	2372.5	a	0.16	93.3	a	2164.1	a
2X - MAP + HA	500.3	a	2400.0	a	0.18	96.0	a	2582.0	a
LSD	48.90		25.1		-	2.50		296.4	
CV%	13.3		1.5		-	3.8		18.9	
P-value	NS		NS		-	NS		NS	
P-value (Check vs rest)	NS		NS		-	NS		0.03	
Check	-		-		-	-		1948.7	b
Rest	-		-		-	-		2280.1	a
P-value (MAP vs MAP+HA)	NS		NS		-	NS		NS	
P-value (1X vs 2X Rate)	NS		NS		-	NS		NS	

MAP - Monoammonium phosphate; MAP + HA - Monoammonium phosphate coated with humic acid; Check vs rest - Control (0P) vs MAP treatments; 1X rate – 25 kg P_2O_5/ha; 2X rate - 50 kg P_2O_5/ha

Table 13: Statistical analyses and treatment mean for flax yield, plant density, dry matter, and maturity response to MAP rates and humic acid-coated MAP at Outlook, SK 2023. Means within a column followed by the same letter do not significantly differ (LSD, P ≤ 0.05).

Entry	Plant Density		Dry Matter		Tissue P	Maturity	Seed Yield	
	(plants/m²)		*(kg/ha)*		*(%)*	*(days)*	*(kg/ha)*	
Control (0P)	337.3	a	2982.3	a	0.24	128.0	2100.4	a
1X - MAP	287.3	ab	2667.3	a	0.29	128.0	2174.7	a
1X - MAP + HA	306.8	ab	3208.7	a	0.26	128.0	2122.1	a
2X - MAP	235.5	b	2578.7	a	0.25	128.0	2038.5	a
2X - MAP + HA	259.8	b	3720.5	a	0.29	128.0	2338.3	a
LSD	34.90		617.7		-	-	147.6	
CV%	17.3		28.8		-	-	9.7	
P-value	0.09		NS		-	-	NS	
P-value (Check vs rest)	0.04		NS		-	-	NS	

Check	337.2	a	-	-	-	-
Rest	272.3	b	-	-	-	-
P-value (MAP vs MAP+HA)	NS		NS	-	-	NS
P-value (1X vs 2X Rate)	NS		NS	-	-	NS
1X	297.0	a	-	-	-	-
2X	247.6	b	-	-	-	-

MAP - Monoammonium phosphate; MAP + HA - Monoammonium phosphate coated with humic acid; Check vs rest - Control (0P) vs MAP treatments; 1X rate – 25 kg P_2O_5/ha; 2X rate - 50 kg P_2O_5/ha