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Growth and Yield of Corn, Carrot and Onion Treated With Rock Phosphate Organic Fertilizer Grown in Standoff Soil Southern Alberta, Canada

Adebusoye O. Onanuga[1], Roy Weasel Fat[1] & Roy M. Weasel Fat[1]

[1] Red Crow Community College, Standoff, Alberta, Cananda

Correspondence: Adebusoye O. Onanuga, Indigenous Agriculture Program, Red Crow Community College, Standoff, P.O. Box 1258, Cardston, AB T0K0 0KO, Cananda. Tel: 587-999-4250; 403-393-2258. E-mail: adebusoyeo@redcrowcollege.com

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Abstract

An experiment was performed in Standoff, Southern Alberta to investigate resource cheap rock phosphate organic fertilizer application to corn, carrot and onion plots. The objective of the study was to ascertain effectiveness of rock phosphate organic fertilizer to support growth and yield of corn, carrot and onion crops grown in Southern Alberta. The varying levels of rock phosphate at 50 P kg/ha for Low P, 100 P kg/ha for High P and control were applied to corn, carrot and onion plots. These treatments were replicated three times, resulting into nine plants per crop. Agronomical parameters collected were subjected to analysis of variance using Duncan Multiple Range Test for separation of means. Result of the experiment indicated that Low P and High P favoured corn height and number of leaves but did not support other parameters measured due to inadequate rock phosphate applied. It was observed that rock phosphate influenced residual level of P after harvest of corn, carrot and onion. Onion plots had the highest P left in the soil than corn and carrot plots. This studies showed potential of rock phosphate in crop production, if apply in adequate amount and availability of soil moisture, as well as high residual P in the soil after harvest.

Keywords: soil degradation, climate change, residual phosphorus, organic rock phosphate, standoff soil

1. Introduction

Climate change has caused set back to cropping system as a result of soil degradation. Climate change has pushed the earth beyond economic threshold, whereby there are many natural and artificial disasters (FAO, 2008), such as flooding, soil erosion, deforestation, soil degradation, etc. (Oldeman, 1994; FAO, 2007; Loder & Wang, 2015). There are many degraded soils around the world caused by over usage of chemical fertilizer (FAO, 2007; Baligar et al., 2001). The excessive usage of chemical fertilizer negatively affects soil physiochemical and biological composition of the soils, as well as soil structure (Baligar et al., 2001; FAO, 2007). Soil properties in relation to climate change increase atmospheric carbon di oxide level, increase in temperature, and rainfall fluctuation (Brevik, 2003). Climate change has changed soil composition, as result of excessive usage of chemical fertilizer (Brevik, 2003). However, organic farming by application of rock phosphate could able to alleviate this world wide problem (Zapata & Roy, 2004). Organic farming is sustainable, environmentally safe, economic viable and social acceptable (Rajan et al., 1996; UNEP, 2000). Organic farming increases biodiversity whereby soil harbours lots of biological biota to improve soil structure. The activities of fauna and flora breakdown organic matter and make essential nutrients available for plant uptake (Chien & Menon, 1995b). There are different sources of organic fertilizer, this study used rock phosphate fertilizer as a source of organic fertilizer. Rock phosphate is a sedimentary rock mined and grounded to powder (Chien & Friesen, 1992). There are benefits in direct application of rock phosphate to the field (Chien & Friesen, 1992). Rock phosphate provides phosphorus and other nutrients to the soil such as nitrogen, magnesium, potassium, manganese and other micro nutrients (Chien & Van Kauwenbergh, 1992). Application of rock phosphate has been proved by Dawn (2000) that it reduced effect of global warming by reducing carbon emission from the soil. Application of rock phosphate to soil is very sustainable in the sense that it has high residual effect whereby phosphorus in the soil is available to subsequent next season plants (Perrott & Wise, 2000). The use of rock phosphate is primitive in Canada as a source of organic phosphorus fertilizer and there is limited literatures reported on rock phosphate organic fertilizer treated with corn, carrot and onion crops. Therefore, this study would ascertain effect of organic rock phosphate applied to Standoff, Southern Alberta soil cultivated with corn, carrot and onion crops

2. Materials and Methods

2.1 Site Description

The experiment was conducted over 2020 Summer time, from April 2020 to September 2020 in Standoff Alberta, Canada. It is located on latitude 49^o North and longitude 113^o West. Its location is on Hwy 2, 43 km South West of Lethbridge. The annual average temperature and rainfall are -1 to 12 ^oC and 515 mm, respectively. Standoff soil is a Brown Chernozemic soils that are found in the Southern part of Alberta.

2.2 Physico-Chemical Soil Composition

Soil samples at 0-15 cm were taken for physico-chemical analysis (Table 1). Nitrate-Nitrogen was extracted in the soil using 0.01M calcium chloride and N was detected by colorimeter. The phosphorus was extracted using modified Kelowna method and read by auto flow colorimeter while potassium was extracted from the soil using 1N neutral ammonium acetate. Micro nutrients were extracted from the soil using DTPA and measured by atomic absorption spectrophotometer (AAS). Soil texture was done using Sodium Hexametaphosphate, measured by hydrometer.

Table 1 shows physico-chemical analysis of the soil used in this experiment. The major essential nutrients Nitrogen (N) was deficient, Phosphorus (P) was optimum and Potassium was excess. Moreover. secondary nutrients such as Calcium (Ca) and Magnesium (Mg) were optimum whereas Sulphur (S) was deficient in the soil. Micro nutrients such as Zinc (Zn), Boron (B), Copper (Cu) and Sodium (Na) were low in the soil while soil Iron (Fe) and Manganese (Mn) were excess. The pH of the soil was 7.6 (soil: water = 1:1). Soil texture was silty clay loam.

Table 1. Physic-chemical properties of corn, onion and carrot field soil trial

Properties	Soil
N (kg/ha)	13.45
P (kg/ha)	117.70
K (kg/ha)	1943.60
S (kg/ha)	17.90
Ca (ppm)	4466.00
Mg (ppm)	580.00
Zn (ppm)	3.00
B (ppm)	1.1
Cu (ppm)	1.30
Fe (ppm)	25.80
Mn (ppm)	11.20
Na (ppm)	11.30
OM (%)	6.00
pH	7.7
EC	0.60
Saturated Bases (%)	
Ca	76.00
K	7.60
Mg	16.30
Na	0.20
ECEC	29.30
K/Mg	0.46
Sand %	19.9
Silt %	42.1
Clay %	38.0
Textural class	Silty clay loam

2.3 Experimental Design

The total area used in this trial for rock phosphate application on corn, carrot and onion plots was 450 m × 150 m = 67,500 m^2 The application of fertilizer was done on April 30, 2020. Rock phosphate was broadcasted to entire experimental field; high level of rock phosphate was applied at 100 P kg/ha while Low rock phosphate applied at 50 P kg/ha and control received no rock phosphate application. Organic rock phosphate fertilizer was applied at these levels due to considerable amount of inherent P level (117.70 kg/ha) in the experimental soil according to the soil test result (Alberta Agriculture, Food and Rural Development, 2005). The basal application of nitrogen inform of urea was broadcasted at 280 N kg/ha to entire experimental plot. The 0.63 ha (22 rows of Kick off corn variety at rate of 2.27 kg), 0.14 ha of dominion carrots variety (5 rows at rate of 0.23 kg), 0.43 ha of Ontario yellow bulb onion variety (15 rows at rate of 3.63 kg) were planted on May 8, 2020 at a spacing of 30 by 90 cm. Each crop experimental plot was replicated three times treated with Low P, High P and control fertilizer application, resulting into nine plants per each crop for agronomical parameters measurement. One plant was taken from equal uniform tallest growth in each of the replicate of the crops, height of corn plant, height of onion plant, and height of carrot plant were measured by metric ruler, number of leaves of corn, corn ears, onion and carrot plants were measured by counting, corn ears weight, onion bulb weight, carrot weight, fresh carrot and fresh onion shoot biomass were measured by electrical sensitive scale. Furthermore, carrot and onion dry weight were dried in an oven at 60 ^{o}C for 2 days, thereafter measured with electrical sensitive scale, and residual phosphorus level in the soil after harvest of corn, carrot and onion were subjected to chemical analysis of soil test to measure residual phosphorus in the soils using modified Kelowna method and read by auto flow colorimeter.

2.4 Statistical Analysis

The parameters measured were subjected to analysis of variance (ANOVA) using IBM SPSS version 27 software, Duncan Multiple Range Test was used for separation of means.

3. Results

3.1 Effect of Rock Phosphate on Growth and Yield of Corn

It is quite obvious in Table 2 that High P and Low P significantly supported the height of corn at 98 Days after sowing (DAS), where High P increased by 12% over control. Nevertheless, no significant difference was observed at 76, 112 and 131 DAS. However, it was observed that Low P and High P positively influenced number of leaves, but High P was not significantly different from control at 98 DAS. There was 41% increased of Low P over control in leaves production at 98 DAS. There was no significant difference in the effort of the treatments to support leaves production at 76, 112 and 131 DAS.

Table 2. Corn height and number of leaves affected by rock phosphate fertilizer over time

Treatments	Days After Sowing (DAS)							
	Corn Height (cm)				Number of Leaves			
	76	98	112	131	76	98	112	131
Control	9.5	15.10b	16.80	17.30	9.0	9.0b	7.70	7.0
Low P	9.2	16.80a	18.20	16.60	9.7	12.7a	9.30	8.0
High P	10.4	16.90a	17.80	18.00	8.7	10.0ab	7.30	10.0
SE	0.90	0.41	0.70	0.85	0.4	1.40	1.20	1.63

Note. Means with different letters are significantly different Duncan Multiple Range Test (DMRT) $p < 0.05$. SE: Standard Error.

The effect of the treatments on number of corn ears and weight of corm ears were not significantly different throughout the experiment (Table 3).

Table 3. Corn number and weight affected by rock phosphate fertilizer over time

Treatments	Days After Sowing (DAS)			
	Number of corn ears			Weight of corn ears (g)
	98	112	131	131
Control	1.00	2.00	2.00	557.70
Low P	1.70	1.30	1.70	523.90
High P	1.30	1.70	1.70	461.04
SE	0.61	0.40	0.40	161.20

Note. Means with different letters are significantly different Duncan Multiple Range Test (DMRT) $p < 0.05$. SE: Standard Error.

3.2 Effect of Rock Phosphate on Growth and Yield of Onion

Table 4 shows effect of rock phosphate on onion height, number of leaves and bulb weight. The effect of rock phosphate on onion height was obvious at 112 DAS where control (6.60 cm) and Low P (6.50 cm) were significantly higher than High P (5.40 cm). The bulb weight and number of leaves were not significant throughout the experimental period.

Table 4. Influence of rock phosphate fertilizer on onion height, number and bulb weight overtime

Treatments	Days After Sowing								
	Onion Height (cm)			Number of Leaves			Onion Bulb Weight (g)		
	76	98	112	76	98	112	76	98	112
Control	7.50	9.70	6.60a	8.70	9.00	5.70	32.50	103.40	220.70
Low P	6.03	7.50	6.50a	7.70	4.70	8.70	39.03	3.20	233.70
High P	6.70	8.30	5.40b	8.70	9.00	6.70	39.20	118.20	177.90
SE	0.71	1.47	0.33	1.05	2.84	1.60	24.30	26.28	38.70

Note. Means with different letters are significantly different Duncan Multiple Range Test (DMRT) $p < 0.05$. SE: Standard Error.

Effect of rock phosphate on fresh and dry onion biomass were significantly influenced at 112 DAS, Low P at 100.30 g and control at 75.60 g significantly got the same fresh weight biomass while High P plot at 45.30 g gave least, but not significantly different from control. Low P was 33% increased over control. The same trend was noticed for dry weight biomass (Table 5).

Table 5. Influence of rock phosphate fertilizer on onion biomass fresh and dry weight overtime

Treatments	Days After Sowing (DAS)					
	Biomass Fresh Weight (g)			Biomass Dry Weight (g)		
	76	98	112	76	98	112
Control	184.90	175.10	75.60ab	14.30	20.70	7.90ab
Low P	95.30	113.40	100.30a	8.30	11.30	10.70a
High P	87.10	105.20	45.30b	8.50	18.90	4.70b
SE	61.00	40.01	21.03	4.30	6.40	2.20

Note. Means with different letters are significantly different Duncan Multiple Range Test (DMRT) $p < 0.05$. SE: Standard Error.

3.3 Effect of Rock Phosphate on Growth and Yield of Carrot

Table 6 shows that effect of treatments applied did not support carrot height, number of leaves, carrot weight, fresh biomass and dry biomass except number of leaves at 76 DAS, when high P and control gave higher number of leaves than Low P.

Table 6. Influence of rock phosphate fertilizer on carrot height, number of leaves, carrot weigh and fresh and dry weight overtime

Treatments	Days After Sowing									
	Carrot Height (cm)		Number of Leaves		Carrot Weight (g)		Fresh weight (g)		Dry weight (g)	
	76	98	76	98	76	98	76	98	76	98
Control	2.60	2.90	7.30a	5.70	32.50	51.80	11.70	7.90	2.20	1.70
Low P	2.90	2.50	4.00ab	6.00	12.90	31.40	4.90	6.20	0.64	1.20
High P	3.20	3.20	5.30a	6.30	25.40	47.10	7.20	11.70	1.40	2.60
SE	0.32	0.48	1.02	1.40	14.90	15.50	4.30	5.90	0.80	1.30

Note. Means with different letters are significantly different Duncan Multiple Range Test (DMRT) $p < 0.05$. SE: Standard Error.

3.4 Residual Phosphorus in the Soil After Harvest of Corn, Carrot and Onion

Table 7 reveals that residual P level in the soil after harvest of corn at 131 DAS, carrot at 98 DAS and onion at 112 DAS. The residual P in the treated soil and untreated soil grown with corn, carrot and onion were not significantly different.

Table 7. Residual level of soil phosphorus treated with rock phosphate fertilizer harvested at 131, 98 and 112 Days After Sowing for corn, carrot and onion, respectively

Treatments	Residual Phosphorus Level (kg/ha)		
	Corn	Carrot	Onion
Control	57.90	56.04	99.00
Low P	47.10	37.40	82.20
High P	41.80	54.20	78.50
SE	15.90	13.70	16.80

Note. Means with different letters are significantly different Duncan Multiple Range Test (DMRT) $p < 0.05$. SE: Standard Error.

4. Discussion

It was observed from the result that application of rock phosphate at high P (100 kg/ha) and low P (50 kg/ha) rates influenced corn height and number of leaves at 98 days after sowing (DAS). Rock phosphate applied at these rates proved effective at 98 DAS only, but positive effect of the treatments was not effective at 76, 112 and 131 DAS. It may be due to inadequate rock phosphate applied. However, Zapta and Roy (2004) confirmed that incorporation of large applications of rock phosphate (500-1000 kg/ha) followed by a regular maintenance application of P would increase availability of P in the soil, as well as maintaining the P in the soil for easy uptake by plants. Furthermore, Hu et al. (1996), Ditta and Khalid (2016) also confirmed that direct application of adequate quantity rock phosphate could increase crop growth and soil phosphorus levels. Furthermore, inconsistent of rainfall and inadequate of irrigation water could contribute steadily to insolubility of rock phosphate applied (Weil et al., 1994). The same trends were observed for number of corn ears and weight of corn ears. Number of Corn ears and weight of corn ears gave no significant difference as a result of inadequate application of rock phosphate and lack of enough soil moisture to dissolve rock phospahte to support corn ears number and yield (Weil et al., 1994; Hu et al., 1996; Ditta & Khalid, 2016).

It was obvious from the result that onion height, number of onion bulb, onion bulb weight, biomass fresh and dry weight grown on soil treated with rock phosphate and untreated (control experimental plot) soil were significantly the same, except for onion height, onion fresh and dry biomass at 112 DAS. It was noticed that Low P and control had the same onion height and the same onion fresh and dry biomass weight at 112 DAS. The quantity of rock phosphate applied (50 and 100 kg/ha of P), as well as rock phosphate insoluble due to fluctuation of irrigation water could not able to support onion crop growth and yield. Zapta and Roy (2004) confirmed that applications of large quantity rock phosphate greater than 100 kg/ha could be added to soil to release phosphorus for nutrients uptake by plants. Moreover, it was also stated by Weil et al. (1994) that increased soil moisture brought about by rainfall or irrigation, increases PR dissolution.

Nevertheless, the same result was observed for carrot height, number of leaves, carrot weight, carrot fresh weight and dry weight. The treatments applied at 50 and 100 kg/ha and irregular water supply could not favour the growth and yield of carrot throughout the experimental period except number of leaves at 76 DAS (Weil et al., 1994; Zapta & Roy, 2004).

There was no significant difference in residual P level after harvest of corn at 131 DAS, onion at 112 DAS and carrot at 98 DAS due to inadequate low P (50 kg/ha) and High P (100 kg/ha) applied to the soil despite the fact that soil used for this trial had adequate inherent phosphorus in the soil according to soil test result (Table 1). However, Alberta Agriculture, Food and Rural Development (2005) stated that marginal and adequate residual P levels left in the soil of this current study were sufficient for next cropping season. It was noticed that residual P level was highest in onion plots than carrot and corn plots according soil test result. This trial identified corn as heavy usage of phosphorus nutrient.

5. Conclusion

The present trial confirmed the potential of rock phosphate in crop production. However, this experiment showed inadequate application of rock phosphate, as well as insufficient of soil moisture inform of rain fed or irrigation to dissolve P in rock phosphate for effective P uptake by the crops to boost corn, carrot and onion crop production. Regardless of inadequate rock phosphate application and soil moisture, residual P levels left after cropping is adequate for P uptake by next season crop. Therefore, we recommend higher application of rock phosphate than the levels used in this present study and adequate soil moisture for effective P uptake by plants.

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