Title

The determination of the effect of in-furrow applied treatments–Black Urea, Bang P, and Qwemikelp + TE on maize.

Trial Objective

The purpose of this trial was to evaluate the effect of **Black Urea®** and **Bang P™**. In the **Black Urea®** 66%+ **Bang P™** treatment and the **Bang P™** in-furrow and **Bang P™, Qwemikelp + TE**, the phosphate was removed from the standard fertilizer and replaced with **Bang P™** in-furrow. For the **Black Urea® 66% + Bang P™** treatment, the normal Urea was removed from the in-row treatment and replaced with 66% **Black Urea®**. The phosphate was also removed and replaced with a **Bang P™** in-furrow treatment. For the two additional programs, the P was removed from the standard fertilizer and replaced with one **Bang P™** followed up with foliar treatments- Rappid K+ Alexin and then later with **Bang P™** again. The second **Bang P™** in-furrow was followed by **C-Lift™** as a foliar application, then later again with **Bang P™**.

Introduction

Foliar application, is nutrient supplementation through leaves, is an efficient technique of fertilization which enhances the availability of nutrients (Khan et al., 2009). It has been observed that utilization of fertilizers especially urea applied through the soil is not as effective when it is supplied to the plant through foliage than the soil application. This also ensures the ample availability of nutrients to crops for obtaining higher yield. Several researchers justified the idea that nutrients like Nitrogen may be taken through roots and leaves may spread within the plant (Khan et al., 2009). Most plants absorb foliar applied urea rapidly and hydrolyse the urea in the cytosol (Rizk et al., 2013). Previous studies

reveal that foliar application of urea increased the productivity and quality of crops and the N fertilizer efficiency can be increased with foliar application (Khan et al., 2009). Absorption and translocation of foliar applied urea-N are affected by a number of factors including the nutritional status of plants, the developmental stage and age of leaves, properties of leaf surface, weather conditions and application time (Ruan & Gerendas, 2015). On the other hand, there is little information on the benefits of in-furrow application in maize, and studies are scarce concerning the soil application of nitrogen recovered by annual crops, the soil systems through denitrification, volatilization and leaching (Khan et al., 2009). Urea can be supplied to the plants through the foliage, facilitating optimal nitrogen management, which minimizes nitrogen losses to the environment (Khan et al., 2009, Mohsin et al., 2014; Ruan & Gerendas, 2015). The application of urea fertilizers to leaves of plants has given response approximately equal to that of fertilizer applied to the soil (Mohsin et al., 2014).

Plants take up phosphate in the orthophosphate form. **Bang P™** is 90% polyphosphate and 10% orthophosphate. Polyphosphate is converted to orthophosphate over time. This hydrolysis reaction ensures that there is a sustained release of phosphate that can be taken up by the plant. **C-Lift™** is a highly concentrated organic concentrate of fish hydrolysate, kelp and highly refined technical fulvic acids, fortified with urea. One of the benefits is its highly available source of nitrogen that promotes nutrient uptake and utilisation by the plant (Plant Nutrition, 2018). Other products in this trial was **Qwemikelp**, which is a liquid nutrient foliar feed complex with unique seaweed extract combination with macro and micro nutrients, it also aids in that assisting plants in the relief of stress, prevention and correction of nutrient deficiencies (Plant Nutrition, 2018). In this trial, investigations were done to evaluate **Black Urea®** 66%+ **Bang P™** treatment and the Bang P™ in-furrow and **Bang P™ + Qwemikelp**. The P was removed from the standard fertilizer and replaced with **Bang P™** in-furrow. One **Bang P™** in-furrow was followed with foliar treatments – Rappid K+ Alexin and then later with **Bang P™** again. The second **Bang P™** in-furrow was followed by **C-Lift™** as a foliar application, then later again with **Bang P™**.

Methods

Site:	Delmas- Agro centre
Products:	Black Urea®, Bang P™, Qwemikelp, C-Lift™, Rappid K, Alexin
Application type:	In-furrow application, depending on label recommendation and trial requirement.
Application rates:	See attached table below (Table 3)
Crop Description	
Crop:	Maize
Variety:	DKC73-76R
Date of planting:	22 November 2018
Crop rotation:	Maize –soya rotation
Row spacing:	0.75 cm
Row length:	30 m
Rows per plot:	4
Harvest date:	25 June 2019

Standard fertilizer information:

The following standard fertilizer was used at planting:

Fertilizer used	**Kg/ha**
10:1:2 broadcast	500
15:10:6 in row	157

For the **Black Urea®** 66% + **Bang P™** treatment, the normal Urea was removed from the in-row treatment and replaced with 66% **Black Urea®**. The phosphate was also removed and replaced with a **Bang P™** in-furrow treatment. The normal phosphate in the fertiliser blend is 15.7 kg P per ha. This was replaced with 5 lt **Bang P™** per ha which is only 1 kg P per ha.

For the **Bang P™ + Qwemikelp** treatment – all P was removed from the in-row treatment and replaced with 5 lt **Bang P™** and 3 lt **Qwemikelp** was added.

One **Bang P™** in-furrow was followed with foliar treatments – Rappid K+ Alexin and then later with **Bang P™** again. The second **Bang P™** in-furrow was followed by **C-Lift™** as a foliar application, then later again with **Bang P™**.

Normal fertilizer blend (Urea 100%) was the control.

Treatments
Black Urea® 66%
Black Urea® 66%+ Bang P™ (in-furrow)
Bang P™ + Qwemikelp (in-furrow)
Bang P™ (in-furrow) fb (C-Lift™) fb Bang P™ - foliar
Bang P™ (in furrow)fb(Rappid K + Alexin) fb Bang P™ -foliar
Normal fertilizer blend (Urea 100%)

Methods of evaluation/ Evaluation techniques

Plant heights and root length:

Ten randomly selected plants per treatment were marked from two middle rows and measured weekly. Therefore the same plants were monitored each week. The height of treated plants compared to the untreated control was used to determine if the foliage applications caused any delay in growth (stunting). The root length was also measured. The heights and root length of each assessment was subjected to statistical analysis.

Brix readings:

The brix sugar content was determined by using the handheld refracto-meter. Different leaves from the same plant was measured 3 times and then averaged. Weekly evaluations were done.

SPAD Chlorophyll readings:

The leaf chlorophyll content was screened using an AtLeaf handheld chlorophyll meter. The atLEAF sensor is a recently developed inexpensive alternative for SPAD and measures transmittance of light at wavelength of red (660 nm) and near-infrared (940 nm) (Zhu, Tremblay, and Liang 2012). It demonstrates a high degree correlation between the chlorophyll and the absolute pigment content. It measures the leaf greenness, this estimates total chlorophyll in the leaves. Different leaves from same plant were measured 3 times and then averaged. Weekly evaluations were observed. The chlorophyll mean values for each treatment were subjected to statistical analysis. The linear interpolation between an interval of measurement values (AtLeaf Performance Index) API=0 to 100. The default values for the measurement interval minimum is 15 and maximum is 65. CHL values under 15 will result in an API=0 and CHL values greater than 65 will give an API=100.

Yield

Four rows were planted. The mechanical harvester that was used harvested four rows. Data was collected by weighing each bag of harvested grain from each treatment. The harvester was completely emptied before the following treatment was emptied before the following treatment was harvested. Yield data from the four rows was converted into yield per treatment (4 rows) and data was converted to Yield per ha. A sample was taken from each bag and the moisture content was determined with an electronic grain moisture meter (SR6828G Grain Moisture Meter, Cup Type). Yield data was converted into "Dry Yield", taking the moisture content of each treatment into account. Yield was therefore also represented as ''Dry Yield".

Raw Data and Statistical Analysis

All the parameter assessments were subjected to statistics analysis using *Analysis of Variance* (ANOVA), XL-stats program 2019 version.

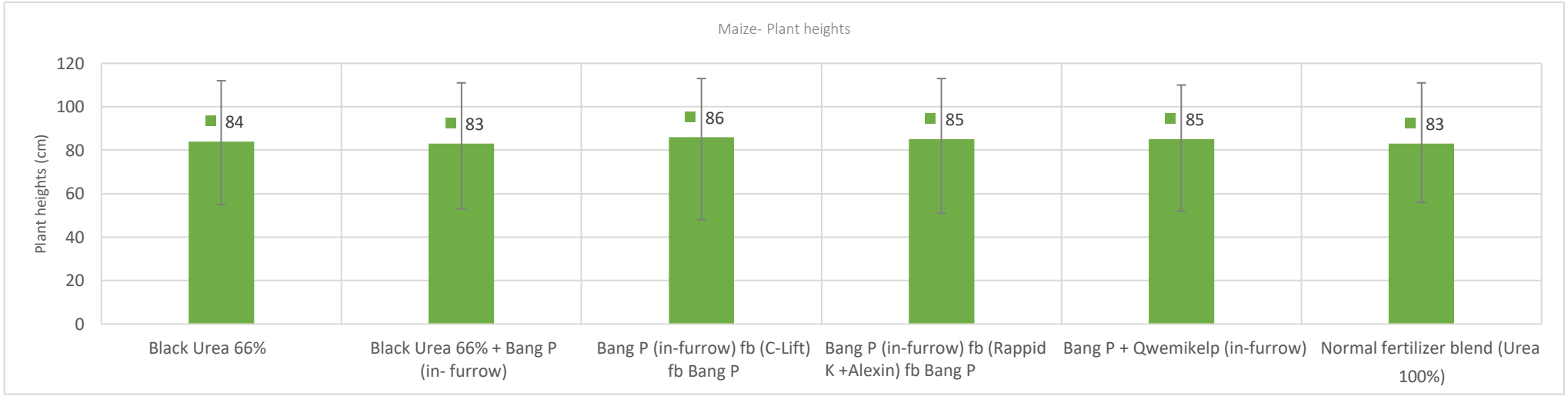
Results

Plant heights:

Treatment	Plant height (cm)
Black Urea® 66%	84
Black Urea® 66% + Bang P™ (in-furrow)	83
Bang P™ (in-furrow) fb (C-Lift™) fb Rappid	86
Bang P™ (in furrow) fb (Rappid K+ Alexin) fb Bang P™	85
Bang P™+ Qwemikelp (in-furrow)	85
Normal fertilizer blend (Urea 100%)	83

Fisher's **LSD** Test:	1.9
Tukey's **HSD** Test:	4.2
Standard deviation (**SD**):	19.3
Standard error of the mean (**S.E.M**):	2.2
Coefficient of variation (**CV**):	0.2%

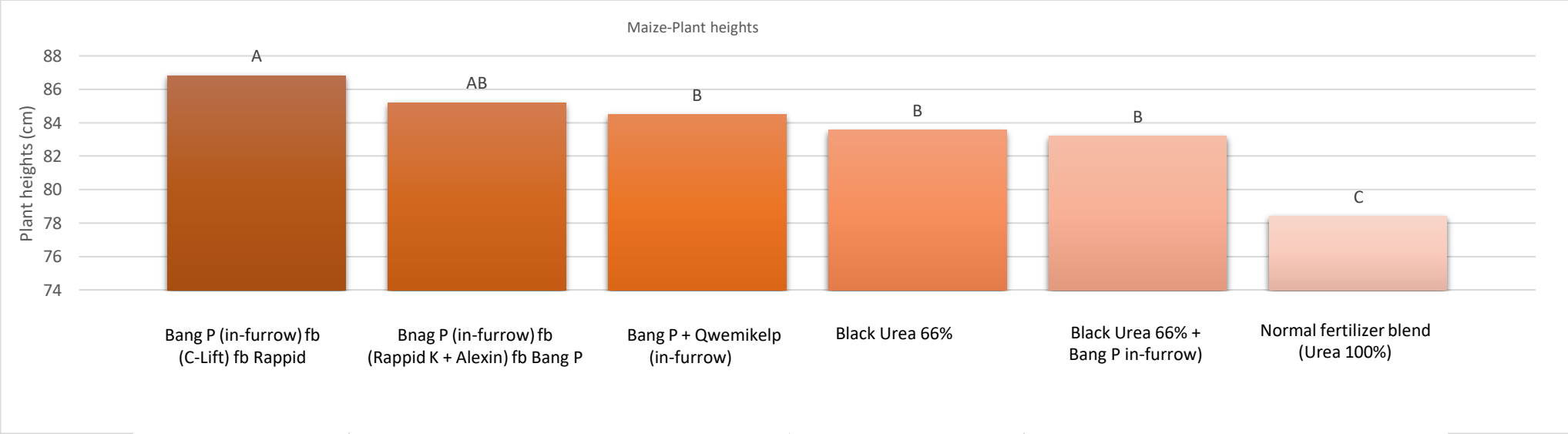
fb; followed by



Discussion:

The highest plant heights were observed on treatments- Bang P™ (in-furrow) fb (C-Lift™) fb Bang P at a mean value of 86 cm. The Bang P™ (in-furrow) fb (Rappid K + Alexin) fb Bang P™ and Bang P™ + Qwemikelp (in-furrow) had similar mean value of 85 cm. This was followed by Black Urea® 66% on its own with a mean value of 84 cm. The Black Urea® 66% + Bang P™ (in-furrow) and the Normal fertilizer blend (Urea 100%) (control) had the lowest plant heights with similar mean values at 83 cm.

The graph below shows the mean values of the plant heights and statistically different among the treatments, the mean values not followed by the same letter differ significantly at a *Least Significant Difference* (LSD) value= 1.9



Root length:

Treatment	Root lengths (cm)
Black Urea 66%	29.8
Black Urea 66% + Bang P (in-furrow)	23.6
Bang P + Qwemikelp (in-furrow)	37.9
Bang P (in-furrow) fb (C-Lift) fb Bang P	35.3
Bang P (in furrow) fb (Rappid K+ Alexin) fb Bang P	27.7
Normal fertilizer blend (Urea 100%)	24.6

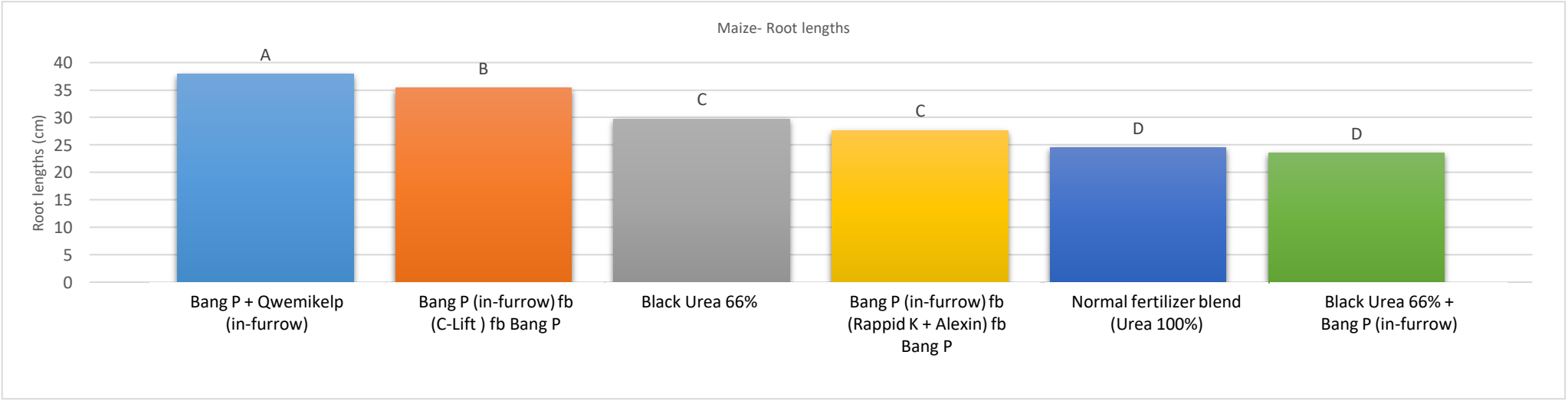
Fisher's **LSD** Test:	2.1
Tukey's **HSD** Test:	4.2
Standard deviation (**SD**):	7.6
Standard error of the mean (**S.E.M**):	1.0
Coefficient of variation (**CV**):	0.3%

fb; followed by

Discussion:

The longest root lengths were obtained with the Bang P™ + Qwemikelp (in-furrow) treatment with a mean value of 37.9 cm, this was followed by Bang P™ (in-furrow) fb (C-Lift™) fb Bang P™ at a mean value of 35.3 cm. The Black Urea® 66% on its own and the second Bang P™ (in-furrow) fb (Rappid K+ Alexin) fb Bang P™ had root lengths at a mean value of 29.8 cm and 27.7 cm. The Normal fertilizer blend (Urea 100%) had root lengths at a mean value of 24.6 cm. The shortest root lengths were observed on Black Urea® 66% + Bang P™ (in-furrow) at a mean value of 23.6 cm.

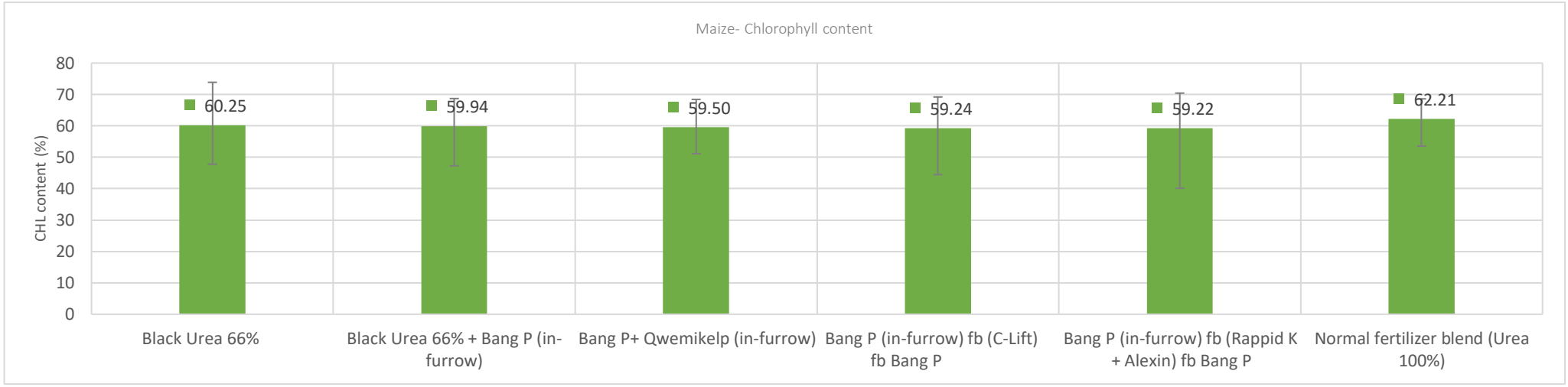
The graph below shows the mean values of the root length and statistically difference between the treatments, the mean values not followed by the same letter differ significantly at a *Least Significant Difference* (LSD) value= 2.1



Chlorophyll content:

Treatment	Chlorophyll content (%)
Black Urea 66%	60.25
Black Urea 66% + Bang P (in-furrow)	59.94
Bang P+ Qwemikelp (in furrow)	59.50
Bang P (in-furrow) fb (C-Lift) fb Bang P	59.24
Bang P (in-furrow) fb (Rappid K + Alexin) fb Bang P	59.22
Normal fertilizer blend (Urea 100%)	62.21

Fishers' **LSD** Test:	4.08
Tukey's **HSD** Test:	4.21
Standard deviation (**SD**):	7.16
Standard error of the mean (**S.E.M**):	0.98
Coefficient of variation (**CV**):	0.12%

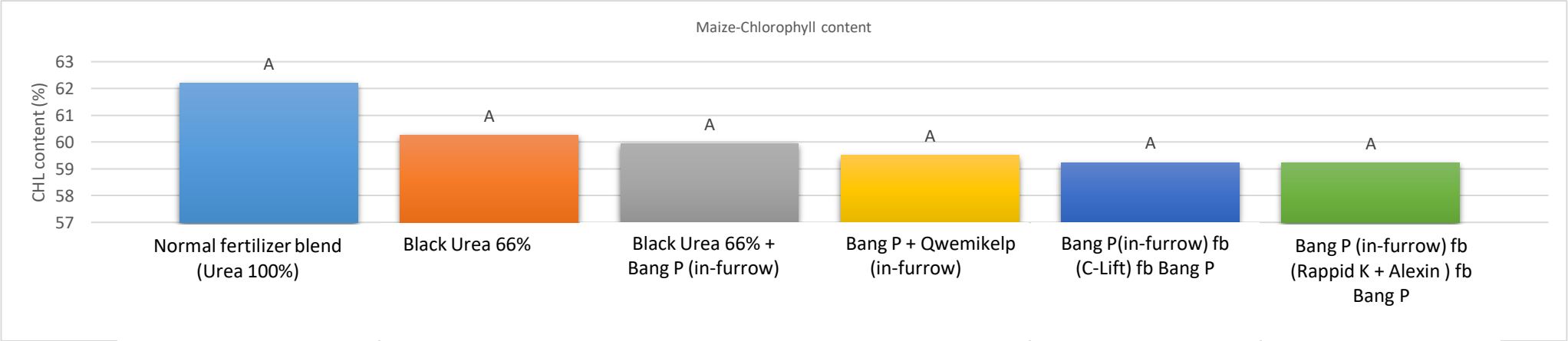


Discussion:

The highest chlorophyll readings were observed on the Normal fertilizer blend (Urea 100%) at a mean value of 62.21%, this was followed by **Black Urea®** 66% on its own had a mean value of 60.25%, this was followed by **Black Urea®** 66% + **Bang P™** (in-furrow) with a mean value at 59.94%. All the **Bang P™** (in-furrow) treatments in combination with Qwemikelp, **C-Lift™** Rappid K and Alexin displayed the same chlorophyll readings at mean values as follows; 59.50%, 59.23% and 59.22%. There was no or little significant difference between the treatments as the readings obtained had a small or same difference among the treatments.

The SPAD Chlorophyll readings are interpreted from the linear interpolation between an interval of measurement values (At Leaf Performance Index) API=0 to API=100. The default values for the measurement interval minimum is 15 and maximum is 65. CHL values under 15 will result in an API=0 and CHL values greater than 65 will give an API=100.

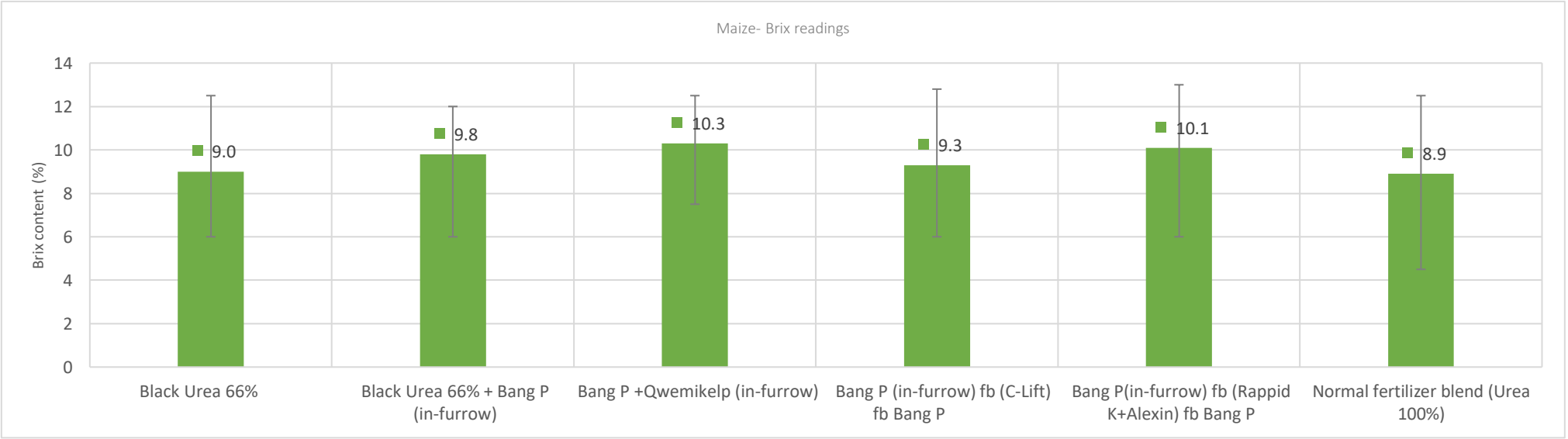
The graph below shows the mean values of the chlorophyll content and statistically different among the treatments, the mean values not followed by the same letter differ significantly at a *Least Significant Difference* (LSD) value= 4.08



Brix readings:

Treatment	Brix readings (%)
Black Urea 66%	9.0
Black Urea 66% + Bang P (in- furrow)	9.8
Bang P + Qwemikelp (in-furrow)	10.3
Bang P (in-furrow) fb (C-Lift) fb Bang P	9.3
Bang P in-furrow) fb (Rappid K + Alexin) fb Bang P	10.1
Normal fertilizer blend (Urea 100%)	8.9

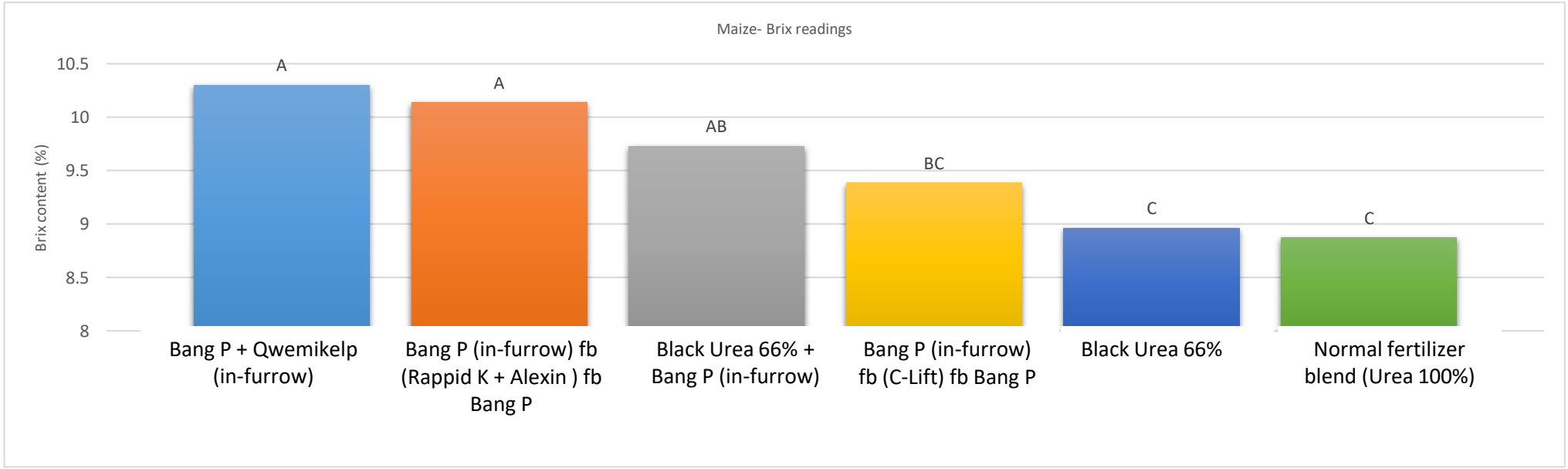
Fisher's **LSD** Test:	0.6
Tukey's **HSD** Test:	4.1
Standard deviation (**SD**):	2.1
Standard error of the mean (**S.E.M**):	0.2
Coefficient of variation (**CV**):	0.2%



Discussion:

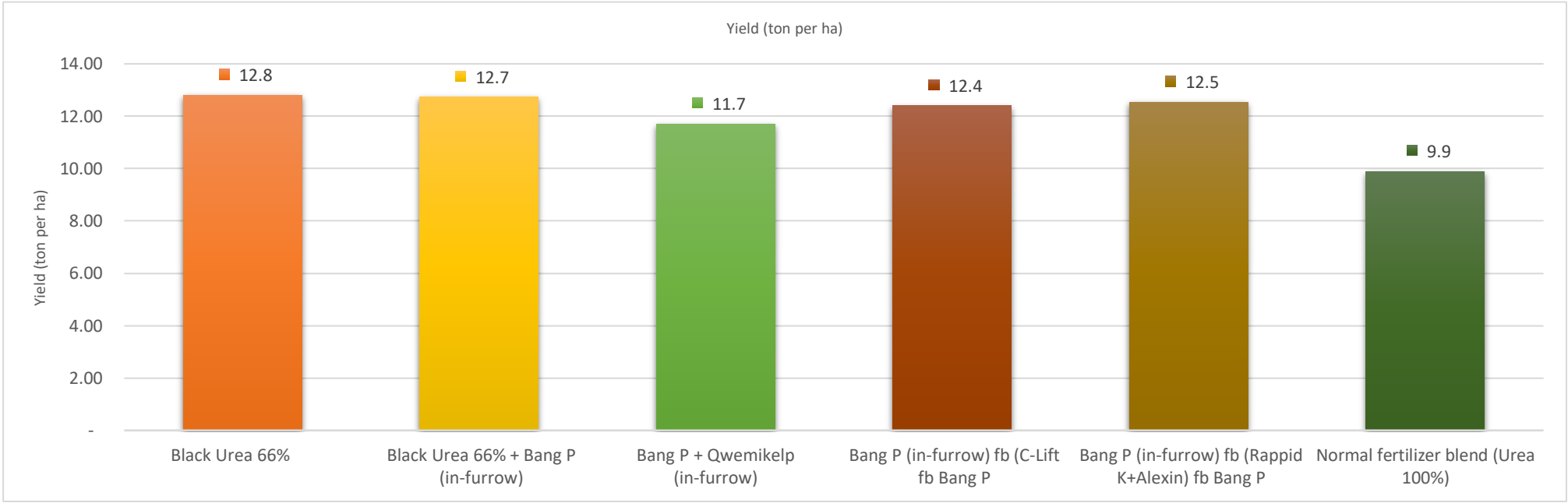
The highest brix readings were obtained on treatments- **Bang P™** + Qwemikelp (in-furrow) and **Bang P™** (in-furrow) fb (Rappid K + Alexin) fb **Bang P™** with mean values at 10.3% and 10.2%. The **Black Urea®** 66% on its own, B**lack Urea® 66+ Bang P™** (in-furrow) and **Bang P™** (in-furrow) fb (C-Lift™) fb **Bang P™** had close mean values at 9.8% and 9.3%. The normal fertilizer blend (Urea 100%) had the lowest brix readings at a mean value of 8.9%.

The graph below shows the mean values of the chlorophyll content and statistically different among the treatments, the mean values not followed by the same letter differ significantly at a *Least Significant Difference* (LSD) value= 0.6



Yield:

Treatments	Dry Yield (ton per ha)
BlackUrea 66%	12.8
Black Urea 66% + Bang P (in-furrow)	12.7
Bang P+ Qwemikelp (in-furrow)	11.7
Bang P(in-furrow) fb (C-Lift) fb Bang P	12.4
Bang P (in-furrow) fb (Rappid K + Alexin) fb Bang P	12.5
Normal fertilizer blend (Urea 100%)	9.9



Discussion:

The highest dry yield were obtained from the treatments- **Black Urea®** 66% on its own at a dry yield of 12.8 ton/ ha, this was followed by **Black Urea® 66% + Bang P™** (in-furrow) with dry yield of 12.7 ton/ ha. The **Bang P™** (in-furrow) treatments with foliar treatments- **C-Lift™** and Rappid K + Alexin had close dry yield at 12.5 and 12.4 ton/ ha. The **Bang P™** + Qwemikelp (in-furrow) treatment had a dry yield of 11.7 ton/ ha was obtained. The Normal fertilizer blend (Urea 100%) had the lowest dry yield obtained at 9.9 ton/ ha, this was the control treatment.

Table 1: Yield Raw Data:

	Moisture content (%)	Wet yield	Moisture weight (kg)	Dry yield per 4 rows	Yield (kg) per ha	Yield (ton per ha)
Black Urea 66%	14.8	137	20.3	116.7	12,798.7	12.8
Black Urea 66% + Bang P (in-furrow)	14.6	136	19.9	116.1	12,735.1	12.7
Bang P + Qwemikelp (in-furrow)	14.6	125	18.3	106.8	11,705.0	11.7
Bang P (in-furrow) fb (C-Lift) fb Bang P	13.7	131	17.9	113.1	12,396.2	12.4
Bang P (in-furrow) fb (Rappid K+ Alexin) fb Bang P	14.7	134	19.7	114.3	12,533.1	12.5
Normal fertilizer blend (Urea 100%)	14.9	106	15.8	90.2	9,891.0	9.9

Table 2: Evaluations taken per assessment:

Parameters	**Evaluation date**
Plant heights	14 January 2019
Root lengths	21 January 2019
SPAD chlorophyll content	28 January 2019
Brix readings	28 January 2019
Leaf Sampling	15 January 2019

Table 3: Products used, rates and application type:

Treatments	**Variety**	**Appl type**	**Standard Fertilizer**	**Rates**	**4- 6th leaf stage**	**Date**	**Before flowering**	**Date**
Bang P (in-furrow)	DKC73-76R	In-furrow	Std Fert – P	5l/ha	Rappid K + Alexin	08 Jan 2019	Bang P	28 Jan 2019
Black Urea 66%	DKC73-76R	In-furrow	Std Fert - N	114 kg/ha				

Black Urea 66% + Bang P (in-furrow)	DKC73-76R	In-furrow	Std Fert – N & P	5 l/ha , 3l/ ha				
Bang P + Afrikelp (in-furrow)	DKC73-76R	In-furrow	Std Fert - P	5l/ha, 3l/ha				
Bang P (in-furrow)	DKC73-76R	In-furrow	Std Fert - P	5l/ha	Genie Marine	08 Jan 2019	Rappid	28 Jan 2019
Normal fertilizer blend (Urea 100%)	DKC73-76R		Standard Fert- N	114 kg/ha				

Table 4: Leaf Analysis for Maize leaf samples:

	ICP Perchloric Acid Digestion mg/kg

Client Ref:	Ca %	Mg %	K %	Na mg/kg	S %	P %	Fe mg/kg	Mn mg/kg	Cu mg/kg	Zn mg/kg	B mg/kg	Mo mg/kg	N %	Al mg/kg
Bang P (in-furrow) fb (Rappid K + Alexin) fb Bang P	0.51	0.31	2.37	98.73	0.24	0.32	148.67	75.38	13.18	29.28	4.83	0.19	3.42	82.80
Black Urea 66%	0.50	0.28	2.76	125.19	0.26	0.35	208.14	74.95	12.95	40.31	5.12	0.54	3.09	153.80
Black Urea 66% + Bang P(in-furrow)	0.47	0.33	2.52	99.77	0.23	0.33	185.54	64.64	12.89	30.73	4.46	0.56	3.10	85.95
Bang P + Afrikelp (in-furrow)	0.37	0.24	2.77	90.99	0.21	0.30	164.36	51.26	10.52	28.20	4.10	0.53	2.20	77.98
Bang P (in-furrow) fb (C-Lift) fb Bang P	0.41	0.29	2.59	111.16	0.23	0.31	216.85	60.04	11.76	33.80	4.97	0.89	2.70	155.90
Normal fertilizer blend (Urea 100%)	0.36	0.32	2.55	94.53	0.19	0.32	145.24	50.87	10.92	24.84	3.76	0.61	2.93	96.07

In the combined treatment, the **Bang P™** (in-furrow) fb (Rappid K +Alexin) fb **Bang P™** showed increased levels of Ca, B and P in the combined treatment when compared to the control and had decreased levels of Mg, K, N and K. However, levels of P were equal when compared to the Normal fertilizer blend (Urea 100%). **Bang P™** contains N and P. Rappid K contains P and K. Alexin contains Ca, Mg, K and B.

Bang P + Qwemikelp (in-furrow) showed high levels of Mg, K, S, Fe, blend Mn, Zn and B when compared to the Normal fertilizer (Urea 100%). The treatment of **Bang P™** + Qwemikelp (in- furrow) showed decreased levels in N, P, K, Cu and Mo when compared to the Normal fertilizer blend (Urea 100%). **Bang P™** contains N and P. Qwemikelp contains N, P, K, S, Mg, Fe, B, Mn, Zn, Cu and Mo.

In the combined treatment, the **Bang P™** (in-furrow) fb (C-Lift™) fb Bang P™ showed increased levels in K and Zn when compared to the control. The treatment had decreased levels in P, N when compared to the control. **C-Lift™** contains N, K, and Zn.

Conclusions and Recommendations

For the **Bang P™ + Qwemikelp** treatment – all P was removed from the in-row treatment and replaced with 5 lt **Bang P™** and 3 lt **Qwemikelp** was added.

Two additional programs were included in the trial where the P was removed and replaced with **Bang P™** and followed up with a combination of products:

- One **Bang P™** in-furrow was followed with foliar treatments – Rappid K+ Alexin and then later with **Bang P™** again.

- The second **Bang P™** in-furrow was followed by **C-Lift™** as a foliar application, then later again with **Bang P™.**

Both treatments with **Black Urea® - Black Urea® 66%** on its own and the **Black Urea® 66% + Bang P™** (in-furrow) had the highest dry yield and the normal fertilizer blend (Urea 100%) had the lowest dry yield.

An increase in 2.9 tons per ha was achieved with the treatment where the nitrogen was reduced to 66% **Black Urea®** with 100% uncoated Urea. Also an increase in 2.8 tons per ha was achieved with the treatment where the nitrogen was reduced to 66% **Black Urea®** instead of 100% uncoated Urea and the P was removed and replaced with **Bang P™** that contained less P, i.e. 1 kg P instead of 15.7 kg P.

Therefore, in this treatment, the Nitrogen of the in-row fertiliser was reduced from 23.55 kg to 15.45 kg and the phosphorous was reduced from 15. 7 kg P to 1 kg P and a higher yield was obtained by using 66% **Black Urea®** and 5 lt **Bang P™**

Bang P™ (in-furrow) followed by (Rappid + Alexin) followed by **Bang P™** had improved yields, followed by **Bang P™** (in-furrow) followed by **C-Lift™** followed by **Bang P™.**

Both **Bang P™,** in – furrow treatments + foliar treatments (**Rappid K and Alexin,** (**C-Lift™**) were foliar applied at the 4th- 6th leaf stage. These treatments were again later foliar applied with **Bang P™**, before the flowering stage.

The yield for both **Bang P™** treatments were the same, also on evaluations assessed, the plant heights, root lengths were increased and fair brix and chlorophyll readings. We can thus, deduce that there was a great effect on this in-furrow and foliar applications at different growth stages.

Bang P™ + Qwemikelp (in-furrow) showed increased plant heights, root lengths and brix readings and fair chlorophyll readings.

The normal fertilizer blend (Urea 100%) which served as a control treatment, showed the lowest dry yield, and all the evaluations undertaken, it showed least results, although in chlorophyll readings it had high readings.

Black Urea® 66% and **Black Urea®** 66% + **Bang P™** has also shown good plant heights and root lengths and fair chlorophyll and brix readings, but when compared to the normal fertilizer blend (Urea 100%), a higher chlorophyll content was obtained than both treatments.

Black Urea® 66% + **Bang P™** (in-furrow) has also shown to play a role in the nitrogen efficiency, where both **Black Urea®** 66% on its own and **Black Urea®** 66% + **Bang P™,** still produced much better yield than the normal uncoated urea 100%.

Based on the leaf analysis report, all the treatments with a high yield- **Black Urea®** 66% and **Black Urea®** 66% + **Bang P™** (in-furrow) has shown high levels of N and P when compared to the Normal fertilizer blend (Urea 100%) even though the N and P that was applied was much less.

Bang P™ (in-furrow) fb (Rappid K+ Alexin) fb **Bang P™** has shown high levels of Ca and B, and decreased levels of N, P, Mg and K when compared to the Normal fertilizer blend (Urea 100%).

Bang P™ (in-furrow) fb (**C-Lift™**) fb **Bang P™** has shown high levels of K and Zn, and decreased levels of N when compared to the Normal fertilizer blend (Urea 100%).

To conclude, reducing nitrogen to 66% **Black Urea®** with 100% uncoated Urea from the standard fertilizer and with replacing the standard fertilizer with **Bang P™** and removing the P from the fertilizer had an effect and improved the dry yield on the maize, in particular, treatments- **Black Urea® 66%, Black Urea® 66% + Bang P™** in-furrow, with foliar applications- Rappid K+ Alexin and **C-Lift™** and later followed up with **Bang P™** again. This could support that foliar applications on different development stages of maize can be beneficial for the growth and increased yield.

References

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