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Enhancing Maize Growth and Yield through Hydropriming in Buuri East Sub-County, Kenya

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Abstract

Maize crop is a source of staple diet in Kenya, providing nourishment for millions of humans as well as livestock. However, the population growth has outpaced the output of maize, due to low crop yield which has been largely attributed to low water status in the plants, leading to poor nutrient uptake and utilization. This study aimed to explore the effects of hydropriming on plant germination, growth vigour and yields of maize in Buuri East Sub County, Meru County. Randomized complete block design (RCBD) was deployed to lay down the experiments. The hydropriming treatments were set at 0 hours, 12 hours, 24 hours, and 36 hours, and effects tested on two maize varieties; namely, H614 and Pioneer 38. Sowing was done on the same day. Data was collected on stem height, leaf length, stem diameter, node length, cob weight, cob length, weight of 100 seeds, and total yields, summarized in Excel and analysed using SPSS version 21. ANOVA was performed to determine which treatments had statistically significant effects at alpha = 0.05. LSD was used to separate the means. Results showed that hydropriming for 24 hrs and 36 hrs had a significant effect ($p < 0.05$) on plant height, leaf length, stem diameter, node length, cob weight, cob length and weight of 100 maize grains which were parameters for growth vigour significantly affected by hydropriming with 36 hours of soaking performing better. The 36 hour priming yielded highest grain per hectare, producing 9,050kg/ha for H614 and 9,600kg/ha for Pioneer 38 respectively. This was 4-fold compared to the non-primed seeds in both varieties. The study concludes that hydropriming of maize would result in better and improved yields in this area. The study recommends that farmers consider hydropriming at 36-hour priming in order to optimize high seedling growth vigour and total maize yields.

Keywords: *Hydropriming, Maize, Growth vigor, Grain yield*

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1.0 Introduction

In Sub-Sahara Africa, 50% of the population depends on maize for iron, carbohydrates, proteins, minerals, and vitamin B. Africans utilize maize for maize meal, porridge, paste, and beer. Green maize on the cob can be roasted, boiled or baked. All parts of corn plant have some economic significance, they are either used as food or non-food products (Ghareeb et al., 2011). The crop is an essential component of animal feeds used when green for silage, and for flour when dry. Maize is also processed into products such as oil and starch in Africa. Nutrient composition of maize grain is approximately 10% protein, 72% starch, 4% fat, 365kcal/100g energy density, vitamin B, and fibre (Ghareeb et al., 2011). In Kenya, maize is the main staple crop, with reports indicating that out of 5.3 million ha of all food crops reaped, 2.1 million ha was covered in maize crops, accounting for 40% of crop area. Due to its widespread availability and comparatively low prices, maize cereal boasts of a wide number of applications, including source of food for human diets, ingredient for industrial processed foods, livestock feed, as well as non-food products such as acids, starches, and alcohols (Mutyambai et al., 2022).

Approximately 1.5 million hectares of farmland are used for maize production in Kenya, with a projected average annual output of 3.0 million metric tons, translating to an average yield of 2 tonnes per hectare (Ministry of Agriculture, 2011). In the highland regions of Kenya, maize harvests typically vary from 4 to 8 T/Ha, representing 50% (or less) of the hybrids' genetic potential. Uncertain and unreliable rainfall patterns, soil degradation, poor quality seeds, climate change, and unreliable draft power greatly affect crop establishment. These unfavourable conditions in Buuri East Sub-County have contributed to frequent crop failures, which make production of maize crop unnecessarily expensive. Maize yield is usually affected by soil salinity as well as failure of the germinating seedling to utilize available rainfall and nitrogen flush (nitrates), leading to inability to suppress weed competition, pest and disease attack (Farooq et al., 2019).

Priming the seeds in water before they are sown, results in rapid germination, high growth vigor resulting from proper utilization of available soil moisture and nutrients by the young seedlings, thereby circumventing the weeds and evading pest attack (Jamshidiyan et al., 2023). Maize crop production call for upscale through priming as a cheap and effective tool. Seed priming ensures growth vigour which is essential for high crop yield, especially in adverse conditions, usually prompted by harsh effects of climate change. It has been found that hydro-priming procedure for seeds improves yields by boosting seed germination. In order to improve, adapt, and deploy seed priming methodologies in Kenya, there is need for research in hydro-priming. The objective of the study was to determine how seed priming affected the vigour and growth rate of maize seedlings, as well as the final yield of maize grains.

2.0 Materials and Methods

Study area

The field trial was set up at Naari area in the county of Meru, Kenya. The farm is situated 5,199 meters above sea level, 1 km from Gitimene centre, and 0° 30' 0' North and 37° 39' 0' East. According to the results of the soil analysis conducted by the ministry of Agriculture in Buuri Sub-County, the soil is well drained loamy, friable, dark brown, and moderately to extremely deep. The region has a bi-modal pattern in terms of distribution of rainfall. Long rains fall between middle of March and extends to May, with short season rains coming between October to December. The rains range between 380 mm to 2,500 mm pa, with an annual average of about 1, 300 mm. The temperature ranges between 10° C to 30° C (DAOS Report, 2020).

Field Experiments

Completed experiment embodied a randomised complete block design (RCBD). Leaving 1 meter between the blocks, eight treatments were randomly distributed in each of the three (3) blocks. The experimental units measured 3.5m by 2m, and the space between consecutive units within the block was 0.5m. Certified seeds were subjected to priming for 36 hours, 24 hours, and 12 hours respectively. Primed maize seeds were then sown directly by hand in furrows, two seeds per 4 cm deep hole, at a spacing of 75 cm by 50 cm. A handful of well rotten farmyard manure and one tablespoonful of NPK per hole were thoroughly mixed with the soil during planting. Table 1 provides a summary of the variables in the experiment, while table 2 shows the treatment combinations applied in this experiment

"The nutrient composition of maize grain has been found by an iconic researcher to be approximately 10% protein, 72% starch, 4% fat, 365kcal/100g energy density, vitamin B, and fibre"

Table 1

Summary of the Experimental Factors

Factor A: Varieties (V)	Factor B: Priming(P)
V1: Hybrid 6214	P0: Control (no priming)
V2: Pioneer 38	P12: Priming for 12 hours
	P24: priming for 24 hours
	P36: Priming for 36 hours

V 1=Variety one, V2=variety two, P=priming, P0= no priming, P12=primed for 12 hours, etc

Table 2

Treatment Combinations

Priming / Variety	P0	P12	P24	P36
V1	V1P0	V1P12	V1P24	V1P36
V2	V2P0	V2P12	V2P24	V2P36

V1P0=variety one not primed, V1P12=variety one primed for 12 hours etc

Plot Layout

There were 3 blocks; each block having 8 plots:

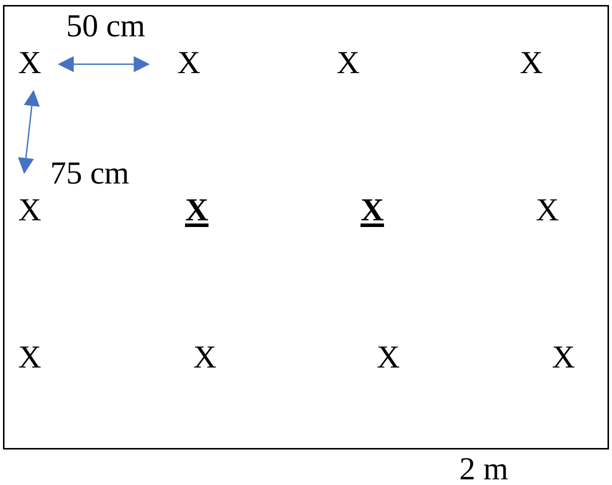
Figure 1

Layout of plots

Block 1							
V1p36	V2p12	V2p36	V1p12	V1p0	V2p24	V2p0	V1p24
Block 2							
V2p12	V2p0	V1p12	V1p0	V1p36	V2p24	V1p24	V2p36
Block 3							
V2p24	V1p36	V2p0	V1p12	V1p24	V1p0	V2p12	V2p36

Table3

Plots Spatial Arrangement



Spatial arrangement of the plant in a plot with the spacing of 75 cm by 50 cm (X) represents the position of the plant; whereas (X) represents plants that were used for data collection.

Field Data Collection Procedures

In order to collect relevant and unbiased data, two plants were randomly chosen and tagged early from every test plot, excluding the border rows. These plants were followed for measurement of various growth parameters progressively throughout the six-month experiment period. The parameters measured included stem height, leaf length, node length, cob length, cob weight, and 100 seed weight and grain yield in kg/ha. The length of the leaf of the sampled plants was recorded in centimetres at an interval of one month after sowing, using a string and a tape measure. Leaf length was measured was from the petiole to the leaf apex; stem length was measured from the stem base using a calibrated stick and a tape measure at an interval of one month (30 days) after planting. The measurements were followed for a period of 180 days from sowing.

Data Management and Analysis

The collected data was keyed in an excel spreadsheet and checked for consistency and completeness and then analysed using SPSS version 21.0 software. Both descriptive and inferential statistical approaches were opted upon in analyses of the data. In order to identify mean differences in performance, Analysis of Variance (ANOVA) was done between treatment combinations; and the differences among means were separated using the least significant difference (LSD) test at 0.05% confidence level.

3.0 Results and Discussion

The effect of hydro-priming on stem height was considered for all the treatments at 0, 12, 24 and 36 hours and measurements taken for a duration of 180 days at 30 days apart. The results are given in Figure 1.

Figure 2

Effects of priming on stem height (cm)

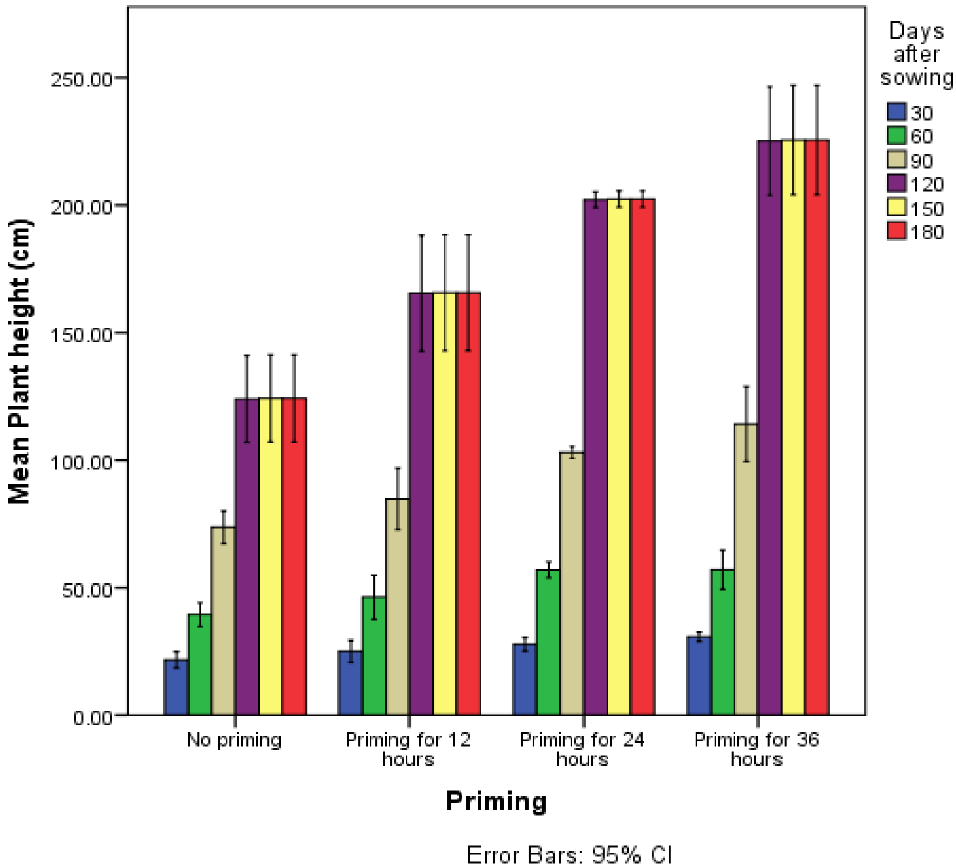


Figure 2 shows that priming did affect stem height in all treatments compared to non-treated seeds. Priming at duration of 36 hours gave significantly higher stem height followed by 24 hours of priming, then 12 hours

Analysis of variance on stem height was as shown in table 3.

Table 4

ANOVA Summary for Effects of Priming on the Stem Height

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
BLOCK	672.441	2	336.221	.071	.931
PRIMING	79846.361	3	26615.454	5.637	.001
VARIETY	4251.692	1	4251.692	.900	.344
Error	646871.143	137	4721.687		
Total	731641.637	143			

Tests of Between-Subjects Effects. Dependent Variable: Plant height (cm)

a. R Squared = .116 (Adjusted R Squared = .077)

The ANOVA summary in Table 4 shows that the blocks and the varieties had no significant effect on the stem height ($P>0.05$), while priming treatment had significant effect ($P<0.05$).

To further confirm which treatments were significantly different between groups, means were compared using LSD, and the results obtained presented in Table 5

Table 5

Effects of Priming on the Stem Height

Priming	Plant height (cm)
0	84.55a
12	108.82ab
24	132.49bc
36	146.37c

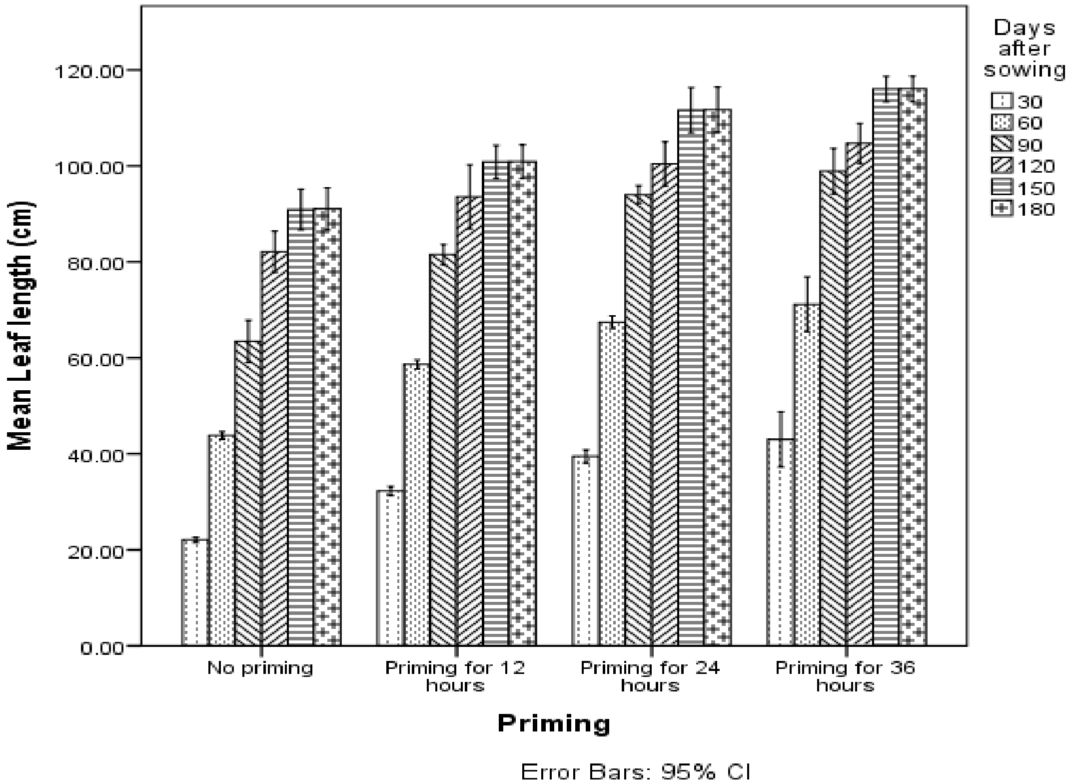
The results in table 5 show that seeds without priming had no significant difference on the plant stem height compared to seeds primed for 12 hours; suggesting that 12 hours of priming was not long enough to affect the stem water status that leads to cell division and elongation in the stem. However, there is significant differences in stem height between seeds primed for 24 and 36 hours. The significant rise in stem height at 36 and 24 hours after priming may have been caused by improved water status in the plant brought on by priming, which aids in the expansion of stem cells due to turgor pressure and cell division, ultimately causing the plant to develop. This finding concurs with the findings of Moaaz et al. (2020) who asserted that stem water status is associated with the plant stem, an organ that connects the leaf source with grain sink, and is crucial in determining developmental status, contributes to plant maturation and development, and improves transportation and distribution of photo-assimilable substances. As a result, normal stem microstructure development and improved stem strength and height of maize plants are a result of stem water status. Jamshidiyan et al. (2023) observes that improved water status in a plant led to strong stems, taller plant height, increased number and area of vascular bundles in the stem. Di Girolamo, (2012) asserts that hydro-primed maize seeds grow shoots that were more consistent and longer than those untreated; while Chivasa et al. (2020) found that primed sorghum seeds were taller and heavier than seedlings that grew from non-primed seeds.

Effect of hydropriming on leaf length

Measurements of leaf length were taken on the randomly selected plants to monitor how this was affected by the priming (Figure 2).

Figure 3

Effect of Priming on Mean Leaf Length



The 36 hours of priming produced a higher leaf length than 24 and 12-hour priming. Non-priming produced the least leaf length. This observation agrees with Farooq et al. (2019) who found out that the number and size of the leaf increased with priming treatment.

Analysis of variance on the effect of priming on leaf length (Table 6), indicates that there was a significance difference in primed seeds, where $p < 0.05$

Table 6

ANOVA Summary for the Effect of Priming on Leaf Length

Tests of Between-Subjects Effects					
Dependent Variable: Leaf length (cm)					
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
BLOCK	91.266	2	45.633	.064	.938
VARIETY	123.377	1	123.377	.174	.677
PRIMING	14472.970	3	4824.323	6.793	.000
Error	97300.329	137	710.221		
Total	111987.941	143			

a. R Squared = .131 (Adjusted R Squared = .093)

To find out which treatments were significantly different, the group means were compared using LSD, and results presented in Table 7.

Table 7

Effects of Priming on Leaf Length

Priming	Leaf Length (cm)
0	65.57a
12	77.96ab
24	87.47bc
36	91.64c

Results in Table 7 indicate that the 36 hours of priming produced a higher leaf length than 12 and 24-hour priming. The explanation for this may be due to improved water status of the plants due to priming, thus increased nutrient uptake which favour vigorous growth of the plant parts. This may also be due to better plant water status regulation in plants of seeds primed for 36 hours, which resulted to improved nutrient uptake which caused a higher vegetative growth due to increased protein synthesis. The findings of Szabó et al. (2022) showed that soaking wheat kernels in water made the rate at which they sprouted better, and increased vegetative growth due to increased protein synthesis. Chivasa et al., (2020) found that Seedlings that grew from primed seeds at 14 days old were also taller and heavier and had more leaves that are longer and more root axes than seedlings that grew from non-primed seeds.

How hydropriming in Maize affects Grain Yield

Data was collected in order to measure how hydropriming of maize seeds at various time points affected the final yields. Statistical analysis of mean grain weights using SPSS 21.0 showed differences in grain yield as presented in figure 3.

Figure 4

Effects on Mean Grain Yield (kgs/ha)

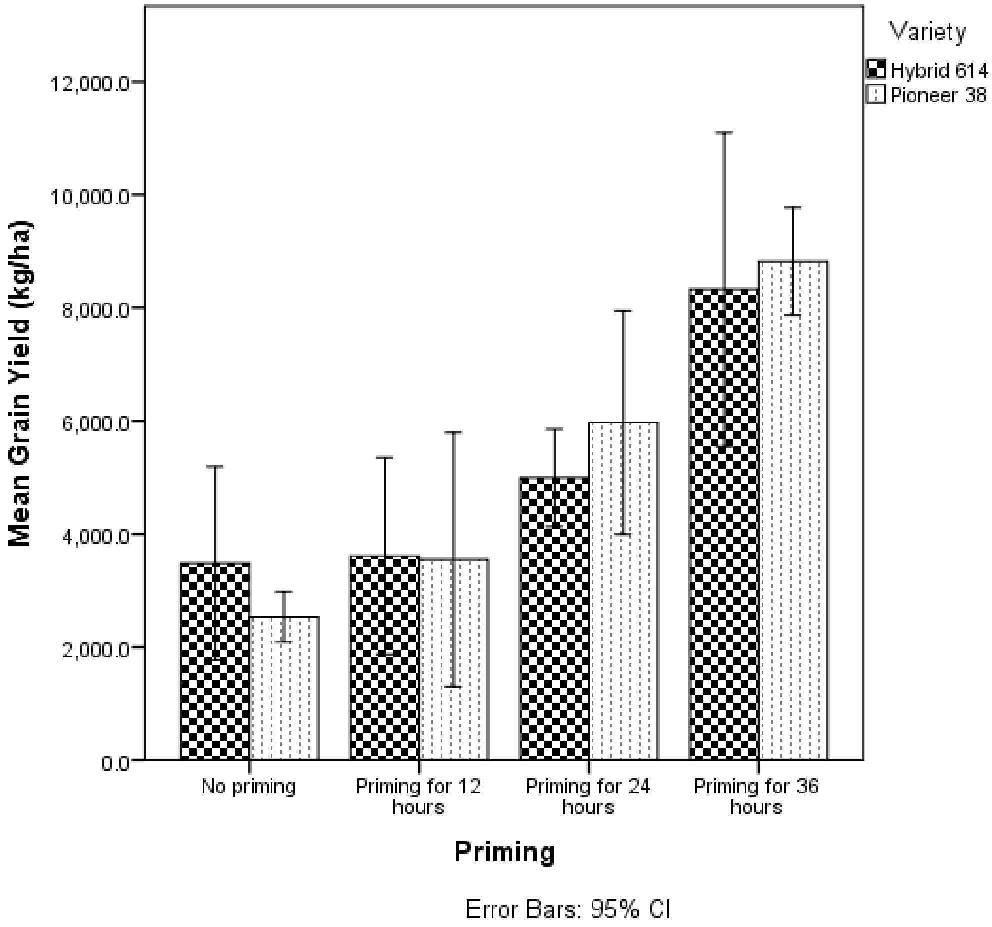


Figure 3 shows that the highest grain yield/ha was given by 36-hour priming, followed by 24-hour priming, then 12 hour priming, and the control test with 0 hours priming having the least grain yields/ha. There was a more observable effect of priming on the P38 variety as compared to hybrid 614.

Table 8

ANOVA Summary for the Effects of Priming on Grain Yield

Tests of Between-Subjects Effects					
Dependent Variable: Grain Yield (kg/ha)					
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
BLOCK	8974.926	2	4487.463	.007	.993
VARIETY	82825.750	1	82825.750	.128	.725
PRIMING	113219107.518	3	37739702.506	58.344	.000
Error	10996325.865	17	646842.698		
Total	124307234.060	23			

a. R Squared = .912 (Adjusted R Squared = .880)

The ANOVA Summary in Table 8 shows that the blocks with 0 hour priming had no significant differences (P>0.05) on the grain yield. However, seed priming treatment had a significant effect (P<0.05). To find out which treatments were significantly different, the group means were compared using LSD and the results presented in table 8

Table 9

Effects of Priming on the Grain Yield

(kgs/ha)

Priming	Grain Yield Kgs/ha
0	3007.35a
12	3580.33a
24	5480.90b
36	8571.33c

Table 9 shows that there was a significant difference (P<0.005) on grain yield of primed seeds when compared with non-primed seeds, but no significant difference (P>0.05) on grain yield comparing non-primed at 12-hour priming. However, there is a significant difference (P<0.05) on grain yield of seeds primed for 24 and 36-hour priming compared to 12-hour priming. The 36-hour priming had a bigger effect on grain yield overall. This can be attributed to increased growth vigour and reduced weed competition resulting to maximum nutrient uptake due to enhanced water status of the plant hence increased RNA and protein synthesis which are essential for high grain yield as previously reported by Verma et al., 2023. They reported that weeds were less enormous because of early and vigorous growth, it enabled the seedling to compete more favourably with the weeds. Superior plant water status management and improved nutrient uptake causes primed seeds to grow quickly (Raj & Raj 2019).

4.0 Conclusion

This study has revealed that, hydropriming for 24 hours and 36 hours had a significant effect ($p < 0.05$) on height of plant and length of the leaf which were parameters for growth vigour; with 36 hours of soaking performing better than all the other two treatment and non- priming. The highest grain yield/ha was given by 36-hour priming treatment, followed by 24-hour priming treatment and the least was non-primed plants. The 36-hour priming could be ideal to achieve maximum grain yield per hectare due to improved water status that lead to improved nutrient uptake and utilization. Further research can be conducted to establish seed priming for other different crops; and on application of different priming methods in maize crop production and their management strategies that aim to improve grain yield and quality.

5.0 Recommendations

Farmers are recommended to adopt 24-hour or 36- hour priming in order to achieve rapid germination, growth vigour and high grain yield if the priming duration meets their needs. The 24 and 36-hour priming treatment employed in this study must be evaluated by farmers in dry areas for suitability with their ecological zones. Farmers should take advantage hydropriming to realize rapid germination, crop growth vigour and high grain yields in other cereal crops especially in the face of climate change. There is need for high maize grain production to meet the food demands by the growing human population, and for livestock feeds. As such, farmers should integrate different technologies to increase maize production. Besides seed priming, farmers also need to pay attention to early and proper land preparation application of nitrogen and management and selection of high yielding varieties. The study recommends 36 hours seed priming of Pioneer 38 variety in Buuri East Sub-County, Meru County, Kenya, for high maize grain production.

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