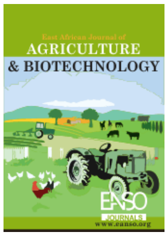

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Original Article

Influence of Cultivars and Intra Row Spacing on Performance of Maize in Keiyo North Sub-County, Kenya

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Cultivars, Grain Weight, Maize Yield, Number of Cobs, Spacing.

ABSTRACT

Maize is a major crop grown in Kenya for human and animal feed. Its production is determined by farming practices such as plant population, climatic factors, pests, diseases and nutrition, among others. Farmers grow maize varieties and are subject to the same spacing, yet they have varying nutrient requirements, resulting in low yields. The objective of this study was to determine the effect of spacing and varieties on quality and yield of maize. A study was conducted between March to December 2019 at Bugar and Tambach in Keiyo North Sub-County, Kenya. The treatments were three plant spacing at 75 cm× 20 cm, 75 cm× 25 cm and 75 cm× 30 cm. The three maize varieties selected were Hybrid 614, Hybrid 624 and Hybrid 6218. A factorial experiment (3×3) in a Randomised Complete Block Design with three replicates was conducted in both sites. Data was collected on the number of cobs, 1000 grain weight and yield per 90kg bag was recorded at the end of the experiment. Data was subjected to two-way analysis of variance and means were separated by Tukey's Honest Significance test at $p \leq 0.05$ in GenStat 14th Version. Results showed that there was no significant difference in interaction between spacing and varieties in both sites. There was significant $p \leq 0.05$ difference on number of cobs in Bugar on spacing but not on variety. The 1000 grain weight was significantly $p \leq 0.05$ different in Tambach for variety but not spacing. H624 under 75 cm×20 cm produced the highest number of cobs in Bugar, while H614 under 75 cm×20 cm was best in Tambach. In conclusion, farmers in Bugar should plant H624 under 75×25cm while those in Tambach should plant H614 under 75 × 30 cm for optimum yields. These should therefore be the recommended spacing for these hybrids in Bugar and Tambach, Elgeyo Marakwet.

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INTRODUCTION

Maize exhibits exceptional productivity per unit area and boasts a broad global production area, surpassing other cereals in these aspects (Bakala *et al*., 2023). Maize is primarily used for animal feed, human consumption, among other use (Bhatt *et al*., 2019). Africa constitutes about 51 million farms, of which 80 % consist of farms less than 2 ha in size (Lowder *et al*., 2016) and they are still increasing in number in most countries (Jirström *et al*., 2011; Headey, 2016). Maize plays a crucial role in global food security, serving as a primary food source for over 300 million people in Africa alone (Blake, 2015; Macauley & Ramadjita, 2015). Maize production in Sub-Saharan Africa (SSA) faces challenges such as low soil fertility, pests, diseases, drought, and inefficient use of inputs (Choufani *et al*., 2017; Fanzo *et al*., 2017). The region experiences yield differences exceeding 100%, indicating significant potential for improvement through the adoption of improved cultivars and production inputs (Leitner *et al*., 2020).

Farmers grow various maize varieties in Keiyo North sub-county of Elgeyo Marakwet County, Kenya. Some of these varieties are H613, H614, H624, H6218 and H513. These varieties have different nutrient requirements, different growth habits, but they are grown and subjected to the same general spacing under the same environmental conditions. This leads to not realising the full yield potential of the maize varieties, then the end results are low yields realised by the farmers. According to Enujeke (2013), various maize varieties yield differently under different spacing conditions. Farmers predominantly use hybrid maize varieties developed by seed breeders to maximise yields. However, a widespread practice among farmers is to use a standard planting spacing of 75cm by 25cm, irrespective of the specific requirements of different maize varieties for spacing and nutrient management for optimal yield. Therefore, examining the effects of spacing under different maize varieties for optimum yield in Keiyo North sub-county of Elgeyo Marakwet County, Kenya, is necessary to optimise maize production.

Farmers would increase their productivity by maximising their planting techniques with a better understanding of the influence of spacing on maize yields. Farmers would know how to maximise their crop yields and raise overall agricultural output by determining the best spacing for various maize cultivars.

Understanding the relationship between spacing and yields aids farmers in maximising the use of inputs and creating plans to handle any potential problems brought on by certain spacing configurations. Examining the effects of spacing under different maize varieties for optimum yield is necessary to optimise maize production. Therefore, the aim of the study was to determine the influence of spacing

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and variety on quality and yield of maize in Keiyo North sub-county of Elgeyo Marakwet County, Kenya.

MATERIALS AND METHODS

Study Site Description

The study was conducted in Tambach and Bugar wards of Keiyo-North sub-county, Elgeiyo Marakwet County, Kenya. The sub-county is located in Iten town, the county's headquarters. It extends from latitude 0° 20″to 1°30′ to the North and longitude 35°0′ to 35° 45′ to the East. The county further consists of three topographical zones, named highland named by locals as" *mosop*" escarpment known as "*lagam*", and lowland" *soin*." These three topographical zones are situated in a north-south direction parallel to one another. The highlands zone is located at an altitude of 2400 to 2700 meters above sea level, while the lowlands are at the foot of Kerio Valley, where the Kerio River flows (Toroitich *et al*., 2024).

Source and Selection of Maize Seed Varieties

The hybrid maize seeds were sourced from Kenya Seed Company which invests significant resources in research and development to produce high-quality seeds. These seeds are often developed through selective breeding or genetic modification to enhance desirable traits such as disease resistance, yield potential, and adaptability. This ensured that the maize seed were genetically superior with a higher chance of producing healthy and productive maize plants that can give reliable results. The three maize varieties that were sourced included; H614, H624 and H6218, owing to the fact that they are commonly planted by the farmers in this region.

Experimental Design

The field trials were implemented during the 2019 growing season, which spans from March to December. The experiment was done in a Randomised Complete Block Design (RCBD) with three replications. The RCBD is a popular experimental design used in agricultural research to minimize the effects of variability and increase the precision of comparisons among treatments. Replication refers to the number of times each treatment is repeated within each block. In this case, three replications of each treatment were used. RCBD having three hybrid maize varieties (H614, H624 and H6218) and three plant spacing 75 cm × 25 cm as control, 75 cm × 30 cm, and 75 cm × 20 cm, were used for each experimental site. Each experimental site consisted of a full-factorial, randomised complete block design with split-split plot treatment divided into 3 blocks and then each block was subdivided into 9 plots for each maize variety. The size of the unit plot was 9 m^2 (3m × 3m) and thus the total number of plots was 27. The distances between plots were 1m.

Treatments and Their Combination

Treatments

Spacing

The maize varieties were planted under the spacing of:

i. 75 cm x 25 cm (control)

ii. 75 cm x 20 cm

iii. 75 cm x 30 cm

Maize Hybrid Varieties

These maize hybrid varieties were;

i. H624

ii. H614

iii. H6218

Crop Establishment and Management

A suitable site for the experimental maize plots were chosen, factoring in soil type, drainage, sun exposure, and accessibility. This was done to minimize external factors that could influence the results. The land was prepared first by clearing bushes using a well-sharpened slasher. Ploughing

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and harrowing was done using a fork *jembe* for several times until it got the desirable tilth that facilitate proper seedbed establishment. The plots were prepared according to the design of the treatments (spacing). Fallows were made as per experimental spacing apart by opening 3-4 cm deep furrows with a *jembe*. Nitrogen, Phosphorous and Potassium fertilizer (NPK) was applied to the plots at a rate of 150kg per hectare.

The application was manually done by placing the fertiliser on the planting rows. Seeds were sown at a depth of 2-3 cm at the rate of one seed per hole in April 2019. Two seeds were sown in each fallow, then thinned at 4 leaf stage. First weeding was done at 2 weeks after germination, then after 25 days and repeated again after another 25 days. Only one healthy seedling hill was kept and the rest were thinned out at 14 days. Application of calcium ammonium nitrate (CAN) at a rate of 150 kg per hectare was done when the maize crops attained a knee height. Fall armyworms were controlled using Amigram chemical at a rate of 50g per 20 litres of water. Spraying was done using a Jacto 20-litre knapsack after every two weeks.

Data Collection

The maize was harvested plot-by-plot on December 2, 2019, the last day of the trial. From each plot, ten plants were chosen at random for data collection on yield characteristics (number of cobs, weight of 1000 grains and the weight per bag). Maize cobs were dried in the sun and then shelled by hand before their weights were recorded. Each plot of grains and stalks was properly dried.

Statistical Analysis

Data on yield characteristics were compiled and tabulated in Microsoft Excel for statistical analysis using Genstat version 14th Edition. They were subjected to two-way analysis of variance and Tukey's Honest Significant Difference test was used for comparisons of means to determine significant differences at $p<0.05$. Data was presented in figures.

Equation 1. Experimental model

$Y_{ijkl} = \mu+\beta_i+S_j+V_k+S*V_{jk}+\varepsilon_{ijkl}$

Data was analysed according to the model shown in Equation 1, where;

Y_{ijkl} = Yield

μ = Overall mean

β_i =Block effect

S_j = Effect due to spatial arrangement

V_k = Effect due to variety

$S*V_{jk}$ = Effect due to interaction between spatial arrangement and variety

ε_{ijk} = Residual error

RESULTS

Response of Optimal Yield Parameters (Number of Cobs, Weight of 1000 Grains & Weight per 90 kg Bag) under Different Maize Hybrid Varieties and Spacing Regimens

Yield on the Number of Cobs under Different Maize Hybrid Varieties and Spacing Regimes in Bugar and Tambach

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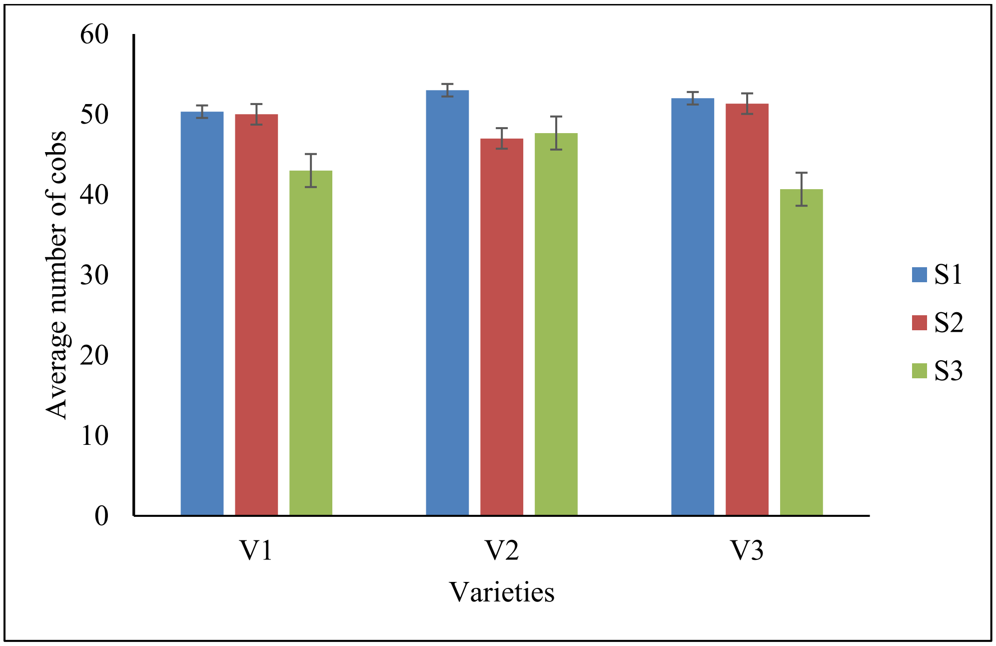
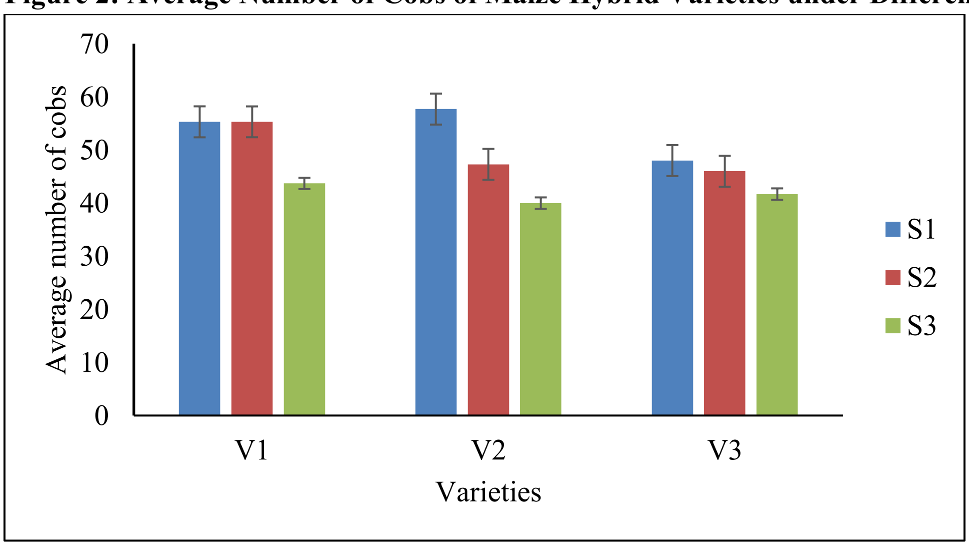
Figure 1: Average Number of Cobs of Maize Hybrid Varieties under Different Spacing at Bugar



There were significant differences ($p \leq 0.05$) in spacing on the average number of cobs in Bugar (Figure 1). However, there were no significant differences ($p \leq 0.05$) in varieties on the average number of cobs. S_1 (75 cm× 20 cm) recorded significantly ($p \leq 0.05$) higher (52) number of cobs compared to S_2 (75 cm× 25 cm) at 49 and 44 in S_3 (75 cm× 30 cm). The average number of cobs was highest (49) in V_2 (Hybrid 624) then followed closely by both V_3 (Hybrid 6218) and V_1 (Hybrid 614) at 48.

Figure 2: Average Number of Cobs of Maize Hybrid Varieties under Different Spacing at Tambach



There were significant differences ($p \leq 0.05$) in spacing on the average number of cobs in Tambach (Figure 2). However, there were no significant differences ($p \leq 0.05$) in varieties on the average

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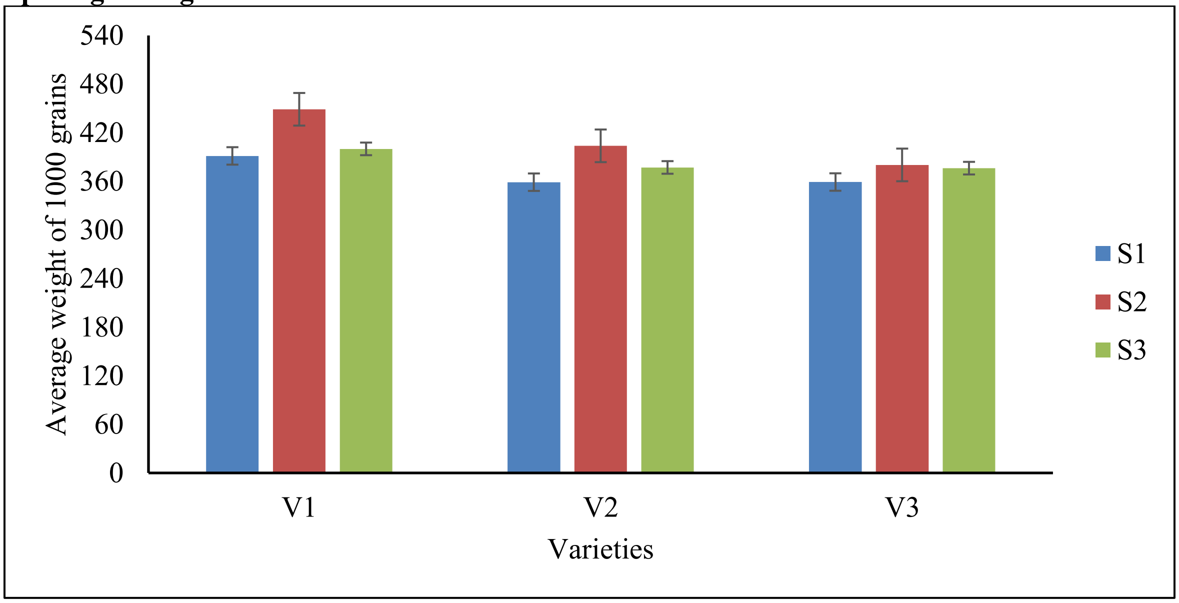
number of cobs. S_1 (75 cm× 20 cm) recorded significantly ($p \leq 0.05$) higher (54) number of cobs than S_3 (75 cm× 30 cm) at 42. The S_2 (75 cm× 25 cm) at 50 did not differ significantly ($p \leq 0.05$) from S_1 and S_3. The average number of cobs was highest (51) in V_1 (Hybrid 614), then followed by V_2 (Hybrid 624) at 48 and V_3 (Hybrid 6218) at 45.

Yield on Weight of 1000 Grains of Different Maize Hybrid Varieties and Spacing Regimens in Bugar and Tambach

Figure 3: Average Weight of 1000 Grains of Different Hybrid Maize Varieties under Different Spacing at Bugar



There were no significant differences ($p \leq 0.05$) in spacing and varieties on the average weight of 1000 grains in Bugar (Figure 3). S_2 (75 cm× 25 cm) recorded the highest (411g) average weight, followed by S_3 (75 cm× 30 cm) at 384g and the lowest (370g) was recorded in S_1 (75 cm× 20 cm). The average weight of 1000 grains were highest (413g) in V_1 (Hybrid 614), then followed by V_2 (Hybrid 624) at 380g and lowest (372g) in V_3 (Hybrid 6218).

Figure 4: Average Weight of 1000 Grains of Different Hybrid Maize Varieties under Different Spacing at Tambach

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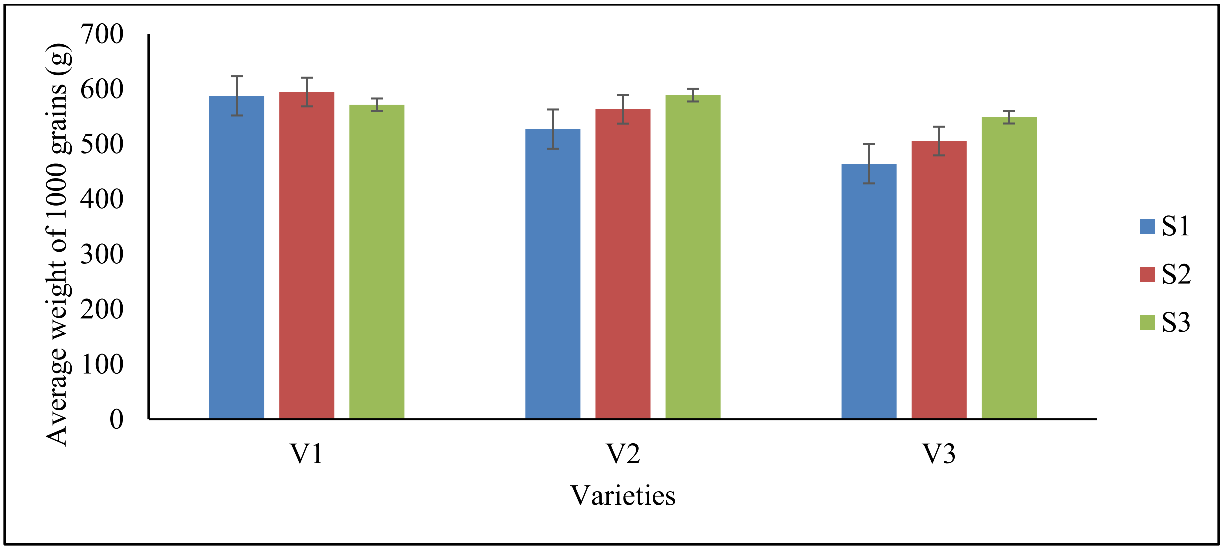
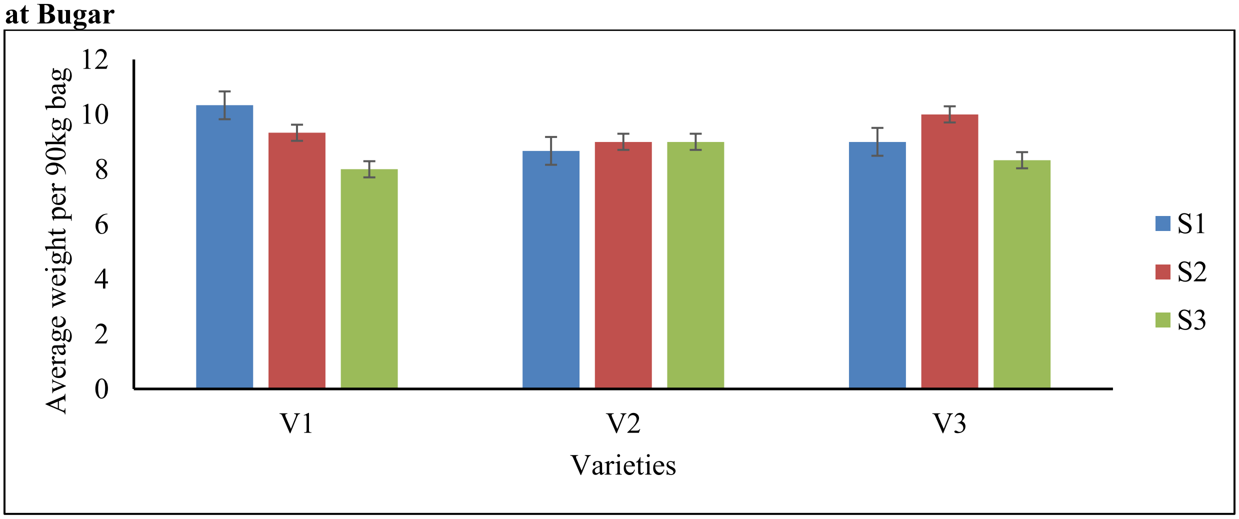


There were significant differences ($p \leq 0.05$) in varieties on the average weight of 1000 grains in Tambach (Figure 4). However, there were no significant differences ($p \leq 0.05$) in spacing on the average weight of 1000 grains. S_3 (75 cm× 30 cm) recorded the highest (569g) average weight followed by S_2 (75 cm× 25 cm) at 554g and lowest (526g) was recorded in S_1 (75 cm× 20 cm). The average weight of 1000 grains were significantly lowest (506g) in V_3 (Hybrid 6218) compared to V_2 (Hybrid 624) at 560g and V_1 (Hybrid 614) at 584g.

Yield on Weight per 90kg Bag of Different Maize Hybrid Varieties and Spacing Regimens in Bugar and Tambach.

Figure 5: Average Weight per 90kg Bag of Different Maize Hybrid Varieties under Different Spacing at Bugar



There were no significant differences ($p \leq 0.05$) in spacing and varieties on the average weight per bag (Kg) in Bugar (Figure 5). Both S2 (75 cm× 25 cm) and S1 (75 cm× 20 cm) recorded the highest (9kg) average weight per bag then closely followed by S3 (75 cm× 30 cm) at 8kg. All varieties, V1 (Hybrid 614), V3 (Hybrid 6218) and V2 (Hybrid 624) recorded the same average weight per bag at 9kg.

Figure 6: Average Weight per 90 kg Bag of Different Maize Hybrid Varieties under Different Spacing at Tambach

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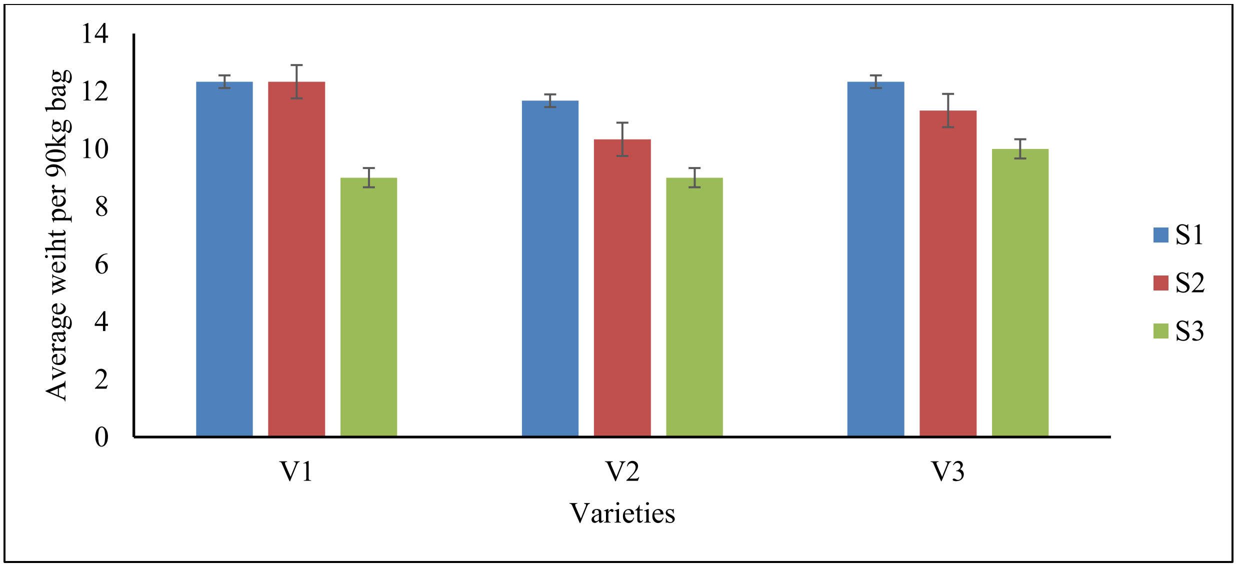

There were no significant differences ($p \leq 0.05$) in spacing and varieties on the average weight per bag (Kg) in Tambach (Figure 6). The average weight per bag was highest (12kg) in S_1 (75 cm× 20 cm), then followed by S_2 (75 cm× 25 cm) at 11kg and lowest (9kg) in S_3 (75 cm× 30 cm). Two varieties, V_3 (Hybrid 6218) and V_1 (Hybrid 614), recorded similar (11kg) average weight per bag, higher than V_2 (Hybrid 624) at 10 kg.

DISCUSSIONS

Response of Optimal Yield Parameters (Number of Cobs, Weight of 1000 Grains & Weight per 90kg Bag) under Different Maize Hybrid Varieties and Spacing Regimes

Yield on the Number of Cobs under Different Hybrid Maize Varieties and Spacing Regimes

S_1 (75 cm× 20 cm) recorded the highest average number of cobs while S_3 (75 cm× 30 cm) recorded the lowest in both Bugar and Tambach. This concurs with a study by Shaka *et al*. (2019) where the lowest number of cobs was recorded at the widest inter-row spacing of 85 cm, while the highest cob number was recorded at the narrowest inter-row spacing of 55 cm.

The average number of cobs was highest in V_2 (Hybrid 624) and V_1 (Hybrid 614) in Bugar and Tambach respectively. This could be attributed to genetic differences that exist between maize varieties with respect to yield. This is similar to the finding of Odeleye and Odeleye (2001) who reported maize varieties differ in their growth characteristics, yield and its components.

Yield on Weight of 1000 Grains of Different Maize Hybrid Varieties and Spacing Regimes

S_3 (75 cm× 30 cm) recorded the highest average weight in Tambach, while S_2 (75 cm× 25 cm) recorded the highest average weight of 1000 grains in Bugar. This is supported by the fact that spacing can influence the availability of resources such as water, nutrients, and sunlight for each maize plant. Optimal spacing allows plants to access sufficient resources, leading to robust growth and higher grain weight. Wider spacing can provide each plant with ample resources, potentially promoting larger grain size and weight, which concurs with Fischer *et al*. (2019) findings. S_1 (75 cm× 20 cm) recorded the lowest average weight of 1000 grains in both Bugar and Tambach. If spacing is too dense, competition for resources can limit individual plant growth, resulting in smaller grain size and weight.

V_1 (Hybrid 614) recorded the highest average weight of 1000 grains while V_3 (Hybrid 6218) recorded the lowest in both Bugar and Tambach. The difference could have been due to the fact that hybrid maize varieties are bred for specific traits,

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including grain size and weight. Different hybrid varieties may have inherent genetic differences in terms of their average weight of 1000 grains. Some hybrids may naturally produce larger and heavier grains, while others may have smaller and lighter grains (Abdoulaye *et al*., 2018). These genetic differences can contribute to variations in the average weight of 1000 grains across different hybrid maize varieties. The findings are in line with those of Gebre *et al*. (2019) that different hybrid maize varieties have difference production capabilities.

Effect of Planting Spacing and Maize Hybrid Varieties on Average Weight per 90 kg Bag

Both S_2 (75 cm× 25 cm) and S_1 (75 cm× 20 cm) recorded higher average weight per 90kg bag, while S_3 (75 cm× 30 cm) recorded the lowest in both Bugar and Tambach. According to a study by Tollenaar and Lee (2002), the spacing between plants in a maize field can have a significant impact on the yield and quality of the crop, whereby narrower plant spacing can lead to increased plant density, which can result in higher yields per unit area. This is because the plants are able to utilise efficiently the available resources, such as light, water, and nutrients, more efficiently in a denser arrangement. Similarly, a study by Sangoi *et al*. (2002) investigated the effect of plant spacing on the performance of different maize hybrid varieties. The result was that the optimal plant spacing can vary depending on the specific characteristics of the hybrid variety. Some varieties may perform better under closer spacing, while others may thrive in more widely spaced arrangements.

All varieties, V_1 (Hybrid 614), V_3 (Hybrid 6218) and V_2 (Hybrid 624) recorded average weight per 90kg bag ranging from 9kg to 11kg in Bugar and Tambach. This could be due to the genetic characteristics of the hybrids, as well as their adaptability to the local environment. It's worth noting that the performance of maize hybrids can be influenced by various factors, such as soil fertility, climate, and management practices (Bänziger *et al*., 2006). Therefore, it's important to consider these factors when evaluating the performance of different maize varieties.

CONCLUSION AND RECOMMENDATIONS

The optimum yields were obtained when maize cultivar H624 was planted at a spacing of 75×25 cm in Bugar, while cultivar H614 was planted at a spacing of 75×30 cm in Tambach. These should therefore be the recommended spacing for these hybrids in Bugar and Tambach, Elgeyo Marakwet County.

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