ID: 200

Evaluation of Adaptability and Performance of Yellow Maize *(Zea mays L.)* under Busogo Environmental Conditions in Rwanda

Charles Dushimirimana[1*], Sylvestre Habimana[1], Saidi Mbaraka Rumanzi[1] & Joyeuse Nyiranshuti[1]

University of Rwanda,College of Agriculture, Animal Sciences and Veterinary Medicine, Rwanda

Abstract

Variations in environmental conditions like temperature, rainfall and humidity are responsible to Maize development and production. This study was conducted within two seasons (Season 2020A and 2020C) with overall objective of evaluating the adaptability and performance of yellow maize under Busogo environmental conditions in Rwanda. Four yellow varieties were used as test plants, and one white variety as a control. The experiment was prepared in a Completely Randomized Block Design (CRBD) with Five treatments and Three replications. The plant management practices were undertaken as per the recommendation for good growth and development. To analyze the collected data (Analysis Of Variance & Means), GENSTAT Software was used to and the mean comparison was done by DUNCAN Method. The results have showed a significant increase in both growth and yield in winter season (Season A) rather than summer season (Season C). Hybrid has more adapted than other varieties in most of parameters with highly yielding. The three varieties originated in the experiment site surrounding areas have showed almost the same performance which might be owing to the almost similar environmental conditions which might be owing to the almost similar environmental conditions.

Key Words: Yellow Maize, growth, yield, adaptability

Introduction

Maize or Corn (*Zea mays*) is a cereal originated under warm, seasonally dry conditions of Mesoamerica and grown widely throughout the world in a range of agro ecological environments. It is one of the three most important cereal crops in the world in terms of area of production. In comparison to different cereals, maize is higher yielding, lower danger, less complicated to manner, and extra flexible with the capacity to develop across agro-ecological conditions (Pulat Batirbaev et al., 2013). Different factors such as genotypes, tillage, nitrogen levels, and climate (temperature and precipitation) impact remarkably on the boom and grain yield of maize amongst others plants (Roshani et al., 2018). The global maize production area is 176 million hectares (Kumar et al., 2012).

Maize has been introduced in Africa, and its cultivation expanded rapidly later in other tropical countries because of its wide climatic adaptability.(Wade H.,2008). Maize production in Africa was around 75 million tons in 2018, representing 7.5% of world maize production. Maize occupies approximately 24% of farmland in Africa and the average yield stagnates at around 2 tons/hectare/year (Nafziger et al.,2013).

Maize was introduced in Rwanda in 1960 and identified as a priority stable crop by the government due to its potential production and use such as playing role in food security, contribution to poverty reduction, used in the production of animals, poultry and fish feed, good crop for fighting hunger as its easier to store (Nafziger et al.,2013). In Rwanda, almost all of the country's agro-climatic zones are highly suitable for maize production (Umutoni J. 2013), with highest average grain yield (around 4.5 t/ha) compared to other cereals grown in Rwanda, such as wheat (2.1 t/ha) and rice (3/ha). In terms of cultivated area and output, maize ranks third (14%) in production in Rwanda, followed by bean (21,2%) and banana (21,2%) production (19.6 %) (Ngabitsinze, 2015).

Rwanda has experienced a problem of insufficient quantity and quality of maize through local production. There is a need of importation from outside country. The estimated quantity of maize requested (marketed) in Rwanda amounts to 55,000 tons per year, of which only about 30,000 tons are from domestic production, suggesting a deficit of about 25,000 tons per year, which is met by imports from Uganda and Tanzania (Pulat et al, 2013).

To serve the growing demand for maize while reducing the current reliance on imported maize grain, the Government of Rwanda has adopted the policy of stimulating the significant growth of maize production through its support and focus on replacing Open Pollinated Varieties (OPV) including yellow maize varieties with high-performance white maize hybrids (Lead, 2016), and this has resulted the decline of yellow maize varieties whiles those are wholesome and high in nutritious value than the ordinary white maize, because of its higher levels of lutein, carotenoids and vitamin A (Kaul et al., 2019).

Yellow maize is a very healthy treat for us all, which is why it is a staple food in many parts of the world. It is an excellent source of fiber and proteins whilst being low in fat and salt. Yellow maize contains lots of minerals

Turkish Journal of Agriculture - Food Science and Technology
Türk Tarım - Gıda Bilim ve Teknoloji Dergisi
International Peer-Reviewed Journal | ISSN: 2148-127X
www.agrifoodscience.com
Turkish Science and Technology Publishing (TURSTEP)

which are important for us and that too in a great quantity (USAID, 2016). The stalks of Yellow maize might be utilized as grain for creatures like cows, sheep, goats, ponies or some other kind of animals. They may likewise be given to poultry, to improve the chicken egg yellowness (Kaul et al., 2019). It is the reason this study was conducted to evaluate the adaptability and performance of yellow maize under Busogo environmental conditions in Rwanda.

Materials and Methods

Experimental site

The experiment was carried out in the model farm of University of Rwanda-College of Agriculture, Animal Sciences and Veterinary Medicine, Busogo Campus located in BUSOGO Sector, Musanze District, in Northern Province, Rwanda. The study site is characterized by the average temperature of about 15.6oC, 2200m of altitude, 1 0C33' of South latitude, 29 0C33' of East longitude and rain fall of 1400mm per year with the volcanic highland soil (Busogo Meteorological station, 2015). The soil of Busogo is the volcanic highland at 2200m absl. The climate is temperate with mean temperature of 17^{o}C.

Plant materials and experimental design

Four yellow maize plant materials namely BYM1, BYM2, BYM3 and BYM4 (Busogo Yellow Maize) originated from Uganda, Kinigi, Nyabihu and Rubavu, respectively, and one white hybrid namely Pan53 as a control were used in our study.

The trials were prepared in a Completely Randomized Block Design (CRBD) with five treatments and three replications. The seeds were sown during two agricultural seasons namely 2020A(September-February) and 2020C(June-September) at 40 cm x75 cm as spacing with 2 seed per hill, twelve seeds per row (Six hills per row), four rows per plot and twenty-four hills per plot in the prepared plots with the size of 3 m x 3m. The plots were separated at 0.5 m x 0.5 m of distance. For good growth and development, plant management practices like are land preparation, sowing, fertilization, watering, earthing-up and weeding were taken as per the recommendations. Fertilizers were applied at the rate of 1000kg/ha of FYM (Farm Yard Manure) by localized placement method, 100kg/ha of DAP (during sowing) by localized placement method and 50kg/ha of Urea (during weeding and earthling up, six weeks after sowing) by side dressing method.

Data collection

Four plants per plot were used for data collection and harvested at maturity. Individual plant base data as well as plot base data were recorded once a month from 30 to 120 days after sowing on all variates. Collected data on individual plant basis from all randomly selected plants were plant height, length of leaves, length and diameter of cobs which were recorded by measuring with measuring tape and expressed in centimeter (cm); number of leaves, number of ears, number of lines per cob, number of kernels per line recorded by counting their number; total grain yield, weight of cobs, weight of 100 kernels by weighting with balance and expressed in grams.

Data analysis

Microsoft Excel was used for data and table processing. GENSTAT Software was used to analyze the collected data (ANOVA & Means) and the mean comparison was done by DUNCAN method (Duncan Multiple Range Test).

Results and Discussion

Plant height

The study showed a significant effect of environmental factors on all parent materials in season A, and no effect in season C. This is due to favorable environmental conditions in season A as (Lead, 2016) stated that maize in Rwanda benefits from two rainy season, the short rain from September/October to December (season A) and the long rains from February/March to May. In season A, BYM4 manifested as a higher performer with 196.6cm of length. However, BYM2, BYM3 and BYM4 are classified in the same performance group (homogeny); to mean almost the same length of plant. Their source/origin are the surrounding areas of the experiment site, with almost the similar environmental conditions. So, with the agreement of (Lamidi & Michael, 2017) in his statement that those growth/vegetative parameters like plant height might be influenced by environmental/climatic conditions. Our finding might be governed by environmental conditions. In the season C which was featured by high temperature, low relative humidity and low rainfall, the study has showed a non-significant difference (no effect of environmental factors) between varieties with low performance in plant height. This is in conformity with the statement of (Singh *et al.*, 2012) that maize grows well in winter season with low temperature and enough rainfall rather than summer season.

Turkish Journal of Agriculture - Food Science and Technology
Türk Tarım - Gıda Bilim ve Teknoloji Dergisi
International Peer-Reviewed Journal | ISSN: 2148-127X
www.agrifoodscience.com
Turkish Science and Technology Publishing (TURSTEP)

Number of leaves

The study shows a significant difference between all plant materials in season A, with white maize hybrid as a higher performer in number of leaves with 13 leaves per plant. Actually, the number of leaves relates to the number of internodes. According to (Bos *et al.*, 2000), Leaf-appearance rate significantly increased well with temperature varies between 18 and 23°C, although less pronounced above. In agreement with him, the findings of our study might be governed by the climate factors. Besides, in season C, no environmental factors effects expressed which is in the agreement with (Singh *et al.*, 2012) who stated that the vegetative parts of maize develop well in the winter season rather than summer season.

Length of leaves

In season A, the study showed a significant difference between all plant materials that express the effect environmental factors on our maize length leaf. BYM4 has highly performed with 100.89 cm and BYM1 as a lowest performer with 81.92 cm of leaf length in the season A. The three plant materials BYM2, BYM3 and BYM4 originated from the surrounding areas (Kinigi, Nyabihu and Rubavu) of the experiment site and white maize hybrid as well, showed almost the similar and high performance. That might be due to the similar environmental conditions of those varieties' origin regions and the experiment site that might have resulted from their adaptation to environmental factors which feet with the statement of both (Padilla, 2005), where he reported that a final leaf initiation and elongation depend upon the environmental conditions like temperature, sunlight and relative humidity and (Mananze & Pôças, 2019), who has stated that the leaf length and area depend on the climatic condition especially the temperature. In contrast, there was no significance difference between all plant materials in season C. Actually, maize grows well in winter season with low temperature and enough rainfall rather than summer season (Singh *et al.*, 2012).

Number of ears

Both seasons of our study have showed a non-significant difference between plant materials in number of ears per plant, as justified by the homogeneity in group performance classification. In other words, there was no effect of environmental conditions on maize in terms of number of ears per plant. In the agreement with (Roshani *et al.*, 2018) who stated that different factors such as genotypes, tillage, nitrogen levels, and climate (temperature and precipitation) influence remarkably on the growth and grain yield of maize among others crops, the number of ears were governed by the varieties' genetic characteristics. The performance of season A is greater than the season C which might be due to most favorable climatic conditions of season A than season C in terms of maize climatic conditions requirements as (Sindhupalchok, 2016) has concluded in his study that the suitable climate for maize growth and development is in warm weather with moderate rainfall.

Table 1. Plant height for four yellow maize varieties and one white maize hybrid

T	Record frequency							
	30DAS		60DAS		90DAS		120DAS	
	Season A	Season C	Season A	Season C	Season A	Season C	Season A	Season C
Hybrid	84.2b	47.1c	88.7c	66.1c	178.8b	100.0b	194.6bc	132.3b
BYM1	64.2b	86.1b	121.2c	123c	155.2b	156.5a	155.6c	194.2a
BYM2	137a	130.5a	152a	147a	222.8a	201.5a	230.2ab	212.9a
BYM3	117.8a	112.9ab	137.8b	134.2b	238.8a	178.9a	248.1a	203.2a
BYM4	119.9a	124.4a	163.2a	152a	220.1a	186.6a	235.6ab	208.4a
	p=0.004	p=0.003	p=0.001	p=0.002	p=0.008	p=0.005	p=0.004	p=0.018
	CV%=12.6	CV%=18	CV%=12.6	CV%=15.2	CV%=10.7	CV%=14.1	CV%=10.1	CV%=12.5
	LSD=24.878	LSD=34.00	LSD=26.278	LSD=36.689	LSD=40.860	LSD=43.593	LSD=40.467	LSD=45.302

T: Treatments; BYM: Busogo Yellow Maize, DAS: Day After Sowing

Table 2. Number of leaves for four yellow maize varieties and one white maize hybrid

T	Recordfrequency							
	30DAS		60DAS		90DAS		120DAS	
	Season A	Season C	Season A	Season C	Season A	Season C	Season A	Season C
Hybrid	11.42a	9.00b	12.25a	10.25a	13.50a	11.67a	14.08a	12.17bc
BYM1	9.83c	10.42a	10.58c	11.17a	12.00a	11.75a	12.67a	12.75ab
BYM2	11.25ab	10.17ab	12.00ab	11.33a	12.17a	11.36a	13.42ab	11.50c
BYM3	10.83ab	10.25ab	11.42b	10.58a	13.00a	11.58a	13.67ab	12.00bc
BYM4	10.67b	10.75a	11.50b	11.25a	13.00a	12.33a	13.75a	13.17a
	p=0.006	p=0.078	p=0.005	p=0.174	p=0.164	p=0.623	p=0.091	p=0.021
	CV%=3.5	CV%=6.4	CV%=3.1	CV%=5.2	CV%=5.8	CV%=6.6	CV%=4.0	CV%=4.0
	LSD= 0.703	LSD=1.218	LSD= 0.709	LSD=1.072	LSD=1.398	LSD=1.460	LSD=1.011	LSD= 0.918

T: Treatments; BYM: Busogo Yellow Maize, DAS: Day After Sowing.

Turkish Journal of Agriculture - Food Science and Technology
Türk Tarım - Gıda Bilim ve Teknoloji Dergisi
International Peer-Reviewed Journal | ISSN: 2148-127X
www.agrifoodscience.com
Turkish Science and Technology Publishing (TURSTEP)

Table 3. Length of leaf for four yellow maize varieties and one white maize hybrid

T	Record frequency							
	30DAS		60DAS		90DAS		120DAS	
	Season A	Season C	Season A	Season C	Season A	Season C	Season A	Season C
Hybrid	89.18a	83.47b	93.73a	86.67a	93.23a	93.73a	100.8ab	99.60a
BYM1	73.91b	88.40ab	77.73b	90.41a	82.17b	92.73a	89.4b	94.50c
BYM2	95.08a	90.34ab	95.30a	91.44a	96.79a	95.30a	110.9a	99.50a
BYM3	94.87a	87.75ab	95.20a	89.19a	96.89a	96.20a	102.4ab	99.42a
BYM4	94.58a	92.85a	96.84a	93.65a	99.64a	94.67a	105.8a	96.67b
	p=0.022	p= 0.223	p=0.039	p=0.402	p=0.039	p=0.439	p= 0.059	p=0.001
	CV%=8.3	CV%=5.1	CV%=7.1	CV%=5.7	CV%=5.3	CV%=5.7	CV%=7.1	CV%=1.3
	LSD=14.102	LSD=8.448	LSD=12.618	LSD=9.744	LSD=9.146	LSD=9.813	LSD=13.696	LSD=2.174

T: Treatments; BYM: Busogo Yellow Maize, DAS: Day After Sowing.

Table 4. Yield parameters for four yellow maize varieties and one white maize hybrid.

P	Treatments															
	HYBRID		BYM1		BYM2		BYM3		BYM4		P Value		CV%		LSD	
	SA	SC	SA	SC	SA	SC	SA	SC	SA	SC	SA	SC	SA	SC	SA	SC
P1	1.5a	1.3a	1.5a	1.6a	1.1a	1.5a	1.5a	1.5a	1.5a	1.0a	0.217	0.440	15.1	31.8	0.4166	0.854
P2	18.71a	18.32a	16.18a	17.63a	16.43a	15.07a	18.7a	17.88a	18.81a	17.68a	0.318	0.215	11.0	9.5	3.689	3.088
P3	4.807a	4.81a	3.537c	4.107c	4.43ab	4.307bc	4,547ab	4,55ab	4,22b	4,707a	0.001	0.001	5.0	3.1	0.4069	0.263
P4	13.43a	14a	13.1b	12.33a	12.31b	11.85a	12.28b	12.83a	11.9b	13.92a	0.057	0.421	4.6	12.1	1.087	2.970
P5	39.9a	30.64a	27.86a	25.66a	26.95ab	24.1a	30.69ab	27.12a	27.31b	27.27a	0.006	0.363	9.2	13.9	5.203	7.066
P6	8.45a	6.3a	3.69d	4.21a	6.8bc	4.76a	7.91ab	5.11a	6.22c	5.21a	0.001	0.661	9.6	32.9	3.492	3.171
P7	233.9a	218a	75.3c	70.2c	156.2b	145.6b	175.7b	163.7b	137.5b	128.1b	0.001	0.001	15.7	15.9	46.53	43.541
P8	39.8a	25.33a	22.28b	29.3a	41.23a	39.43a	42.2a	37.5a	42.33a	37.47a	0.063	0.182	21.3	21.5	15.06	13.734

P: Parameters; P1: Number of ears per plant; P2: Length of ear(cm); P3: Diameter of cob (cm); P4: Number of lines per cob; P5: Number of kernels/line; P6: Total gain yield(t/ha); P7: Total weight of cob(g); P8: Weight of 100kernels(g); BYM: Busogo Yellow Maize, SA: Season A, SC: Season C

Total weight of 100 kernels and Length of ear

Both seasons of our study have showed a non-significant difference between all varieties in weight of 100 kernels and length of cobs. In other words, there was no effect of environmental conditions on the maize in terms of 100 kernels weight and length of cobs. In the agreement with (Roshani *et al.*, 2018) who stated that different factors such as genotypes, tillage, nitrogen levels, and climate (temperature and precipitation) influence remarkably on the growth and grain yield of maize, the weight of 100 kernels and length of cobs were governed by the varieties' genetic characteristics. Similarly to (Sindhupalchok, 2016), who has stated that the suitable climate for maize growth and development is in cool weather with moderate rainfall, the performance of season A which was characterized by the succession of short rainy season (October-November), and short dry season (December-February) is greater than the season C which was featured by sunny weather (Table 4). However, BYM4 variety showed a little difference in performance in both seasons.

Diameter and weight of cob

Both seasons of our study have showed a significant difference between plant materials in both diameter and weight of cob. In other words, there was an effect of environmental conditions on the maize in terms of cob diameter and weight. However, the performance of season A is greater than the season C which might be due to most favorable climatic conditions of season A which was characterized by alteration of short rainy season (October-November), and short dry season (December-February) than season C which was characterized by sunny weather in regard of maize environmental requirements. In addition, white maize hybrid has more performed than other varieties which might be due to its high performance in vegetative parts development. This is in the agreement with the statement of (Lamidi & Afolabi, 2017) that to increase the yield for maize or/ and other crops, various parameters that make up growth rate like the leaf broadness, leaf length, number of leaf at the particular time and maize stem girth must be well established. Yellow maize variety, BYM1 originated from Uganda adapted well in sunny season(C) than rainy season(A), this might be owing to the high temperature of Uganda compared to Rwanda. Ministry of agriculture animal industry and fisheries in Uganda, stated that maize in Uganda adapts well in warm condition with optimum temperature for plant growth ranges of 30^{o}C – 34^{o}C (MAAIF,2017).

Turkish Journal of Agriculture - Food Science and Technology
Türk Tarım - Gıda Bilim ve Teknoloji Dergisi
International Peer-Reviewed Journal | ISSN: 2148-127X
www.agrifoodscience.com
Turkish Science and Technology Publishing (TURSTEP)

Number of lines per cob

Both seasons of our study showed a non-significant difference between treatments in terms of number of line per cob. In other words, no effect of environmental conditions on the maize in terms of number of line per cob. According to (Dawadi & Sah, 2012), the number of kernel line per cob is significantly influenced by the varieties' genotype. The higher number of kernel rows/ear in his study, all varieties' number of line per cob might be due to its genetic characters. Similarly, to (Roshani *et al.*, 2018), hybrid can be a good option to increase the total production of maize grains with high input in mid-hills and open pollinated varieties as well. The same, our experiment showed white maize hybrid as a highest performer in number of line per cob. Therefore, this variate might be governed by genetic characteristics.

Number of kernels per line

Our experiment has showed a significant difference between treatments in number of kernels per line which means the effect of environmental conditions on our maize in season A and non-significant difference in season C. According to (Struik et al., 1986), the Environmental factors have a great impact on the number of male and female florets of maize, which determine the number of kernels. The same, (Singh *et al*., 2012) has stated that the productivity level of winter grown maize is higher as compared to summer sown maize because of comparatively favorable environmental conditions relating to the maize requirements in terms of such conditions. Also, according to (Andrade & Sadras, 2003), the gain yield was significantly increased as long as water availability increases. For our study, the rainfall in season A(943.9mm) was greater than that of season C (659.4mm). Therefore, the number of kernels per line were affected by rainfall. However, the 4yellow varieties which were originated from the nearest area of the experimental site with of course the almost similar environmental conditions, have showed almost the similar performance with the same group of performance and white maize hybrid as the higher environmentally affected with 37.9 of number of kernels per line. On other hand, in the season C, no significant effect of environmental manifested on our maize due to unfavorable environmental conditions in season C (sunny season).

Total grain yield (t/ha)

There was a significant difference between treatments in the total grain yield in season A. This defines a significant effect of environmental conditions on maize in terms of total grain yield per hectare. However, the white maize hybrid which was a higher performance in both vegetative growth and number of kernels per line, has also showed a high performance in total yield with average yield of 8.46t/ha and 6.30 t/ha in season A and C respectively. This is in conformity with (Ashraf *et al.,* 2015), who stated that an increase in plant growth has eventually yielded more total grain yield. According to the study of (Singh *et al.,* 2012), the total yield gained during winter season was invariably (> 6t/ha) than the summer season yield (2-2.5t/ha).

Conclusion & Recommendations

According to the obtained results from this study, there is a significant increase in both growth and yield in season A (Umuhindo: September-January) rather than season C (Impeshyi/Icyi: June-September). Research has proved that yellow corn, the three yellow plant materials originated from the experimental site surrounding areas have almost the same adaptability. Besides, the yellow plant materials from outside the country is less adaptive, whereby its adaptability is particularly greater in season C than season A. In general, our all plant materials are adaptive in Busogo area.

People may be encouraged to grow the yellow maize and reinforce their consumption as source of vitamin A that may help he government to achieve one of MDGs' goals of hunger and malnutrition eradication. Farmers should grow the maize in season A (September- February) whereby short rainy season (October-November), and short dry season (December-February) are alternating so that good adaptability and productivity. UR-CAVM should plan such experiments for further seasons for accurate evaluation and results and provide further relative researches for evaluating other many OPV varieties' adaptability in the area.

Reference

Ashra W, Sahi ST, Ul Haq I, Ahmed S. 2015. Morphological and pathogenic variability among Macrophomina phaseolina isolates associated with maize (*Zea mays*)in Punjab-Pakistan. International Journal of Agriculture and Biology, *17*(5), 1037–1042. https://doi.org/10.17957/IJAB/15.0020

Bos H J, Tijani-Eniola H, Struik PC. 2000. Morphological analysis of leaf growth of maize: Responses to temperature and light intensity. Netherlands Journal of Agricultural Science, *48*(2), 181–198. https://doi.org/10.1016/S1573-5214(00)80013-5

Dawadi DR, Sah SK. 2012. Growth and Yield of Hybrid Maize (*Zea mays L* .) in Relation to Planting Density and Nitrogen Levels during Winter Season in Nepal. Tropical Agricultural Research, *23 (3): 218 – 227 (2012)*

Kaul J, Jain K, Olakh D. 2019. An Overview on Role of Yellow Maize in Food, Feed and Nutrition Security. International Journal of Current Microbiology and Applied Sciences, *8*(02), 3037–3048. https://doi.org/10.20546/ijcmas.2019.802.356

Kumar B, Karjagi CG, Jat SL, Parihar CM, KR, Singh V, Hooda KS, Dass AK, Mukri G, Sekhar JC, Kumar R, Kumar RS. (n.d.). MAIZE BIOLOGY. what is this?

Lamidi WA, Michael A. 2017. Influence of some environmental factors on maize productivity in Osun state. Ethiopian Journal of Environmental Studies and Management, January 2017 DOI: 10.4314/ejesm.v9i2.7S

Lead A. 2016. Generation Seed Study Generation Seed Study. United States Agency for International Development or the United States Government, *AID-OAA-A-13-00085.*

Nafziger ED. (n.d.). M ES PL C E O – PL C E O –. Growth and production of maize: mechanized cultivation. *Crop Sciences, University of Illinois, Goodwin, Urbana IL 61801, USA.*

Ngabitsinze JC. 2015. Analysis of Economic Efficiency of Maize Production in Huye District in Analysis of Economic Efficiency of Maize Production in Huye District in Rwanda. International Journal of Agriculture Innovations and Research,3,3, ISSN (Online) 2319-1473.

Padilla JM. 2005. Co-ordination between Leaf Initiation and Leaf Appearance in Field-grown Maize (Zea mays). Oxford University Press *(Zea mays),* November 2005, Vol. 96, No. 6 (November 2005), pp. 997-1007.

Pulat Batirbaev, TaeYoung Kim, Rezvan Ma'ani, Ryung Shim, Jen Singer, Matt Snyder FY. 2013. Maize in Rwanda : A Value Chain Analysis. United Nations Industrial Development Organization (UNIDO), Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria

Roshani S, Komal BB, Santosh M, Tika BK. 2018. Performance of maize hybrids under different tillage methods and nitrogen levels. African Journal of Agricultural Research, 13(2), 36–40. https://doi.org/10.5897/ajar2017.12787

Singh N, Rajendran A, Shekha M, Jat SL, Kumar R, Sai Kumar R. 2012. Rabi Maize opportunities & challenges. Directorate of Maize Research (Indian Council of Agricultural Research) Pusa Campus, New Delhi - 110 012 (India).

Umutoni J. 2013. Improving firm-farm relationship in maize production in Rwanda . Case Jeanne Umutoni. University of Applied Science, Wageningen The Netherlands.

USAID 2016. Early generation seed systems study, country report (Rwanda Egs country study). USAID Bureau of Food Security.

Wade H. Reeve 2008. The Biology of *Zea mays L* . ssp mays. The Australian Government, Department of Health and Aging, Office of the Gene Technology Regulator.

Turkish Journal of Agriculture - Food Science and Technology
Türk Tarım - Gıda Bilim ve Teknoloji Dergisi
International Peer-Reviewed Journal | ISSN: 2148-127X
www.agrifoodscience.com
Turkish Science and Technology Publishing (TURSTEP)