ON-FARM EVALUATION OF NEW GREEN GRAM VARIETIES IN THE ARID AND SEMI-ARID AREAS OF EASTERN KENYA

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ABSTRACT
Green gram (*Vigna radiata* (L) Wilczek) is an important staple crop and a source of livelihood to most small scale farmers in the semi-arid of eastern Kenya. The current production of green grams cannot meet its demand in the local and export markets. The available green gram varieties are low yielding, have a small grain size and are late maturing. Farmer's participatory field experiments were conducted in Meru and Tharaka-Nithi Counties to evaluate the adaptability and acceptability of three new green gram varieties. The trials were laid in a Randomized Complete Block Design with four plots replicated thrice. The objectives were to evaluate the green gram varieties for yield under farmer's management, assess the farmers' preferences and test their adaptability in the region. The treatments comprised of green gram varieties; Karembo, Ndengu tosha, Ndengu Biashara and N26 (control). The varieties were planted in plots of 5m x 5m at a spacing of 60 cm x 20 cm and DAP was used as a source of nutrients. The parameters evaluated were grain yield, number of pods per plant and number of seeds per pod. The findings indicated that in Tharaka-Nithi County, Karembo variety was highest in yields with 1.171 t ha^{-1} , an increase of 74.5% above the control (0.671 t ha^{-1}). Biashara variety followed with 1.02 t ha^{-1} ,an increase of 34.4% above the control (0.671 t ha^{-1}). In Meru County, Biashara variety gave the highest yields of 1.99t ha^{-1}, an increase of 362.8% above the control (0.43tha^{1-}). Karembo variety followed with 1.47t ha^{-1}, an increase of 241.9% above the local check (0.43tha^{-1}). The local check (N26) had a grain yield of 0.43tha^{-1}. There was a significant difference ($p<0.05$) among the four green gram varieties on grain yield in Meru County. There was a similar trend for both the number of seeds per pod and number of pods per plant where Ndengu Tosha produced the most seeds per pod and pods per plant in both Tharaka-Nithi and Meru counties with a mean of 15.4 and 18.4 seeds per pod and 25 and 27.6 pods per plant respectively. This was followed by Biashara that produced a mean of 11 seeds per pod and 22.2 pods per plant in Tharaka-nithi and 13.4 seeds per pod 26.6 pods per plant in Meru County. The local variety N26 produced the least number of pods per plant in both sites having a mean of 5.6 seeds per pod and 10.4 pods per plant in Tharaka-nithi and 4.4 seeds per pod, 16.4 pods per plant in Meru County. During the evaluation, the farmers set their criteria for evaluating the performance of the varieties. They used different criteria to evaluate and assess the green gram varieties. The major attributes used in the evaluation included pest and disease tolerance, high grain yield and non-shattering ability. The attributes were ranked through pairwise ranking and the first four were used to rank the varieties in order of preference. Ndengu Biashara ranked highest because of its early maturity and high yields, followed by Karembo and Tosha. The results revealed that adoption of these varieties would increase yields and in turn increase income for the farmers. It would also increase the diversity of varieties in the region. Seed bulking would be an important intervention in dissemination of the new seeds.
Keywords: Green gram varieties, evaluation, farmer's perception, adoption

INTRODUCTION

Green gram commonly known as mung bean (*V. radiate* (L) Wilezek) is an important crop in the warm dry parts of Eastern Kenya. It is commonly grown in Machakos, Makueni, Kitui and Tharaka-Nithi owing to its early maturity (USAID, 2013a). Green gram can be grown at 0-1600m above sea level. It is relatively drought tolerant with rainfall requirement of 650 mm per annum (CBS 2003).It is well adapted to a range of soil types including sandy loamy and clayey soils at pH 5.5 -7.5. It has a high dietary value having 24% protein, 6mg/100g iron, 30g/100 energy and 1.8g/100g fibre. (USDA, 2018). Green grams can be grown as a sole crop or can be intercropped with a cereal crop. In the intercrop, 1-2 rows of green grams are planted between 2 cereal rows (Swaminathan et al., 2012).The green grams have nodules with rhizobia in their roots that fix nitrogen from the atmosphere into the soil, (Jat et., al 2012). Green grams add about 30-40 kg N/ha after harvesting thereby improving soil fertility. This implies that subsequent crops (mainly cereal crops), will require less N application (Mbeyagala et. al 2017).

It is grown for subsistence and commercial purposes. There is emerging demand for green grams in the export market that is driving its production (ITC, 2017). The green gram yield gap is up to 80% where the actual yield is 0.46MT/ha against the potential of 3 MT/ha (Kilimo Trust, 2017).There is an increased demand for green grams in Kenya as a result of the

growing population and increasing prices of other legumes. There is also an increased awareness of the nutritional benefits of green grams leading to increased consumption. Green grams are bought by individuals who account for 50% followed by institutions like hotel industries and schools. This demand does not equal its production due to low, unreliable and scattered production.

The major constrains to green gram production include pests, diseases and use of inappropriate agronomic practices. Green gram is affected by a number of diseases among them, anthracnose, bacterial bean blight, bean rot, powdery mildew, rust and yellow mosaic virus. The most serious diseases are leaf spot and Powdery mildew which reduces yield by up to 30% (Dakshayani and Mummigatti, 2004). Field pests of economic importance include bean fly, thrips, aphids, pod sucking bugs, apion beetle and bruchids (MoARD Kenya, 2002) Control of pests and diseases is usually by use of industrial chemicals (Machocho et al., 2012). This practice is expensive and can lead to health hazards and ultimately detrimental environmental effects. The resource poor farmers who are the main producers and consumers of green grams are unable to effectively control the pests and diseases effectively resulting to relatively low yields. Therefore, there is need to develop and promote appropriate technologies for green gram production. These include the introduction of varieties that are resistant to these pests and diseases.

The available green gram varieties in Kenyan market include N26 and KS 20 and ordinary (Local green gram). The local varieties are characterized by low yield (less than 500 kg/ha) and have long maturity periods (3-4 Months). The seeds are small and pods are prone to shattering before harvest leading to post harvest losses. They are characterized by stoniness and are hard to cook reducing their consumption demand (Karanja, 2016). The production of these varieties is 1300-1500kg per ha. N26 has a maturity period of 75 - 90 days whereas KS20 matures in 80-90 days.

The new green gram varieties are Ndengu tosha Kat 00301, Biashara Kat 00308 and Karembo Kat 00309. They mature in 65-75 days and yield up to 1800-2100kg per ha. Farmers lack information about the new varieties because they have not been evaluated in the area. Farmers in the area are demanding for better yielding and pest resistant varieties to increase their production and in turn increase their income and improve their livelihoods. With productivity of the green grams being below the potential yield of 3MT/ha, there is need to grow and promote high yielding varieties coupled with good agricultural practices to optimize yield. The objectives of this study were to evaluate the adaptability of the new varieties in the area and identify the farmers' preferences for the new green gram varieties.

MATERIAL AND METHODS

The experiment was done in Tharaka-Nithi and Meru Counties of Eastern Kenya. Tharaka-Nithi County lies between latitude 0.0734 and 0.2728 and longitude -37.1824 and -37.4619. It is located in the semi- arid region of Kenya. The county covers a total area of 2,638.8 km^2 with a population of 35,330. It lies in the Eastern slopes of Mt Kenya as the most prominent physical feature in the region. Tharaka South Sub-County lies in the lower midland 4 and 5 (LM4 and LM5) agro-ecological zones. The altitude of the area ranges from 510 to 750 m above sea level. (Jaetzold et al., 2006). The area experiences a bimodal rainfall pattern with mean annual rainfall range of 200-800 mm per annum and temperature range of 11-25.9^oC. The soils are mainly ferralsols which are highly weathered soils. Meru County is located on the North eastern side of the slopes of Mt. Kenya. The agro-ecological zones range from the highlands (UH3) which are moist and have fertile soils with high agricultural potential to the lowland semi-arid areas, LM6 (Jaetzold et al., 2010). The altitude of the County ranges from 300-5199 m (Dolan, 2012). The annual rainfall ranges from 380 in the lowlands to 2500 in the highlands. The area experiences a bimodal rainfall pattern where the long rains are experienced from March to May and the short rains from October to December and has mean temperature of about 18^oC. Meru County covers an area of 6936 km^2. The population is approximately 1,365,301 people.

Research design

The trial was laid out in a Randomized Complete Block Design (RCBD) with plots measuring 5mx5m. The treatments included four green gram varieties (Kat 00301 (Biashara) Kat 00308 (Karembo), Kat 00309 (Ndengu tosha) and N26 (control) replicated three times. The row spacing was 0.60 m and 0.20 m between plants giving 83,333 plants/ha. The planting and management of the trial was participatory done by farmers groups and the KALRO Embu researchers and area agricultural extension officers. Planting was done at the onset of the rains. Diammonium phosphate fertilizer was applied at planting at a rate of 100 kg ha^{-1}. Weeds were controlled through hand weeding.

Variety selection and evaluation criteria

Three new green gram varieties together with the existing N26 were evaluated for their adaption in the areas and their performance in terms of yield. A participatory green gram variety evaluation involving

farmers groups in Meru and Tharaka-Nithi Counties was conducted in farmers' fields during the 2016 short rains and 2017. This was carried out at flowering and physiological maturity stages and at crop harvest. The farmers developed criteria for selecting the varieties by first mentioning the important attributes in selecting green grams varieties. These were ranked using the pairwise ranking criteria in order of their importance. Four highly desired attributes were used to rank the green gram varieties. The attributes included drought tolerance, early maturity, tolerance to pest and disease and high yielding. The farmers used the agreed attributes to score and rank each variety.

Data Collection

The biophysical data was collected on plant and plot basis. Ten plants were sampled at random from which data on number of seeds per pod and number of pods per plant was taken. Grain weight and biomass was collected from the entire plot. The biophysical data was subjected to analysis of variance (ANOVA) using SAS version 8.0. The least significant difference (LSD) at 5% was used to compare the difference among means.

RESULTS AND DISCUSSION

Evaluation of plant physiological traits

Karembo produced the highest yield under on-farm trial in Tharaka-Nithi County with an average grain weight of 1.171 T/Ha followed by Biashara with 1.056 T/Ha and the lowest variety was N26 which produced 0.671 T/Ha. The results showed that there was no significant difference between Ndengu Tosha and Biashara; however, there was a significant difference among the Karembo and N26. The results from Meru County indicated significance difference among all the four varieties (p=0.0007) with Ndengu Biashara attaining the highest yields of 1.99T/Ha, followed by Karembo and Tosha with 1.47T/ha and 1.02 T/ha respectively. The local check (N26) had a grain yield of 0.43T/ha. There was a significant difference among the four green gram varieties for grain yield in Meru.

Table 1. Yield of green grams varieties in Tharaka-Nithi and Meru Counties

Variety	Grain Weight (tha^{-1})	
	Tharaka-Nithi	Meru County
Karembo	1.171a	1.47b
Ndengu Biashara	1.056b	1.99a
Ndengu Tosha	1.016b	1.02c
N26	0.671c	0.43d
Mean	0.979	1.22
CV	26.990	18.03
P-Value	0.0842	0.0007
LSD	0.5277	0.4412

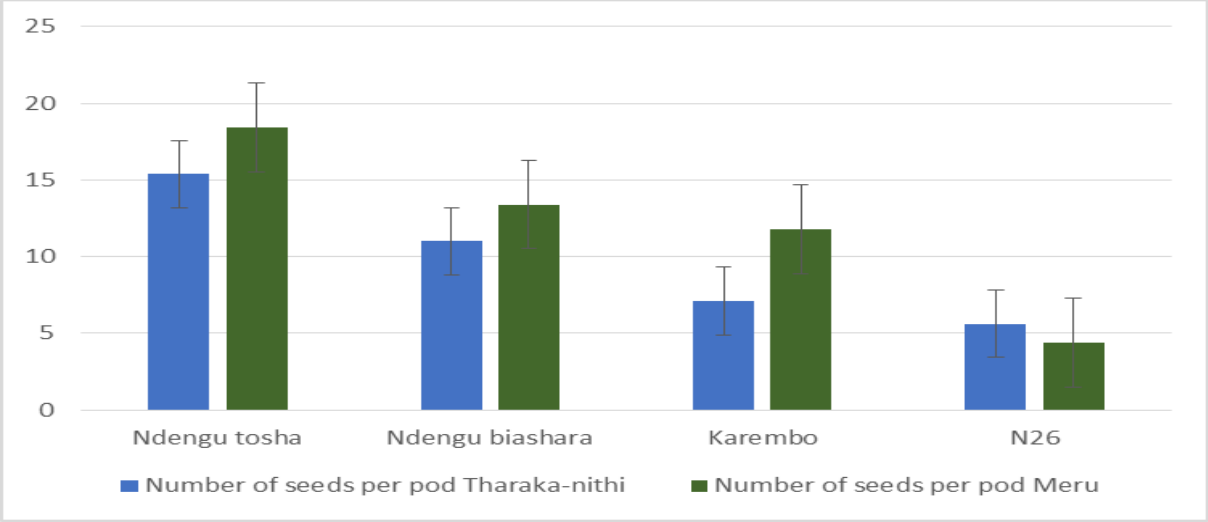

Figure 1. Number of seeds per pod in Tharaka-Nithi and Meru Counties

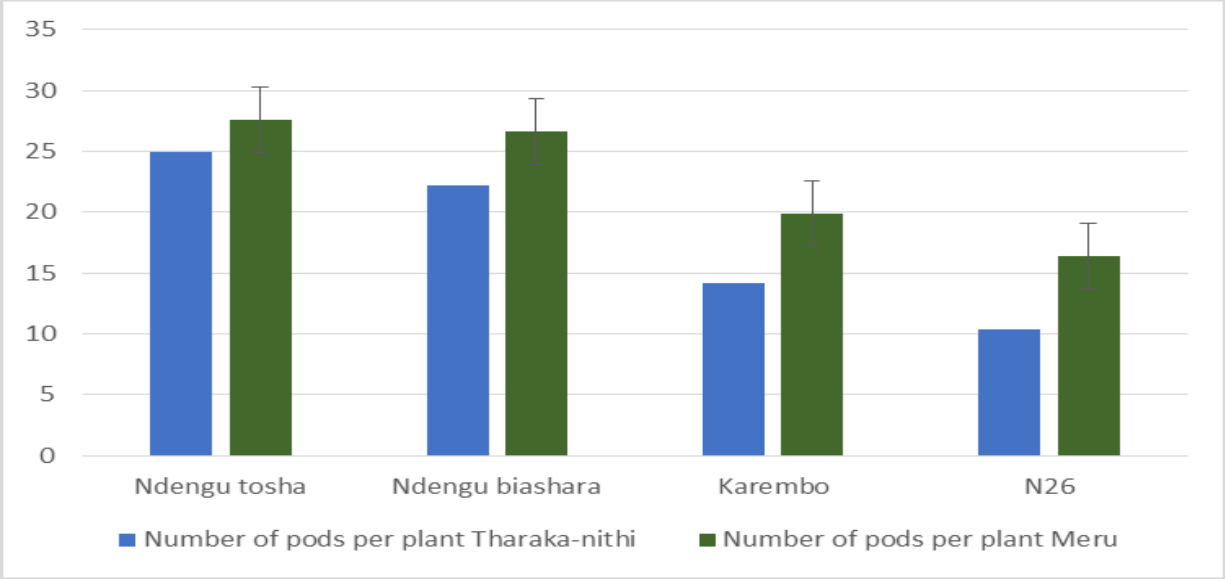

Figure 2. Number of pods per plant in Tharaka-Nithi and Meru Counties

Ndengu Tosha produced the most seeds per pod in both Tharaka-Nithi and Meru with a mean of 15.4 and 18.4 seeds, respectively. This was followed by Biashara that produced a mean of 11 seeds per pod in Tharaka-Nithi and 13.4 seeds per pod in Meru County. The local variety N26 produced the least number of pods per plant in both sites having a mean of 5.6 seeds per pod in Tharaka-Nithi and 4.4 seeds per pod in Meru County.

The number of pods per plant followed a similar trend as that of number of seeds per pod. Ndengu Tosha produced the highest number of pods per plant in both Tharaka-Nithi and Meru counties with a mean of 25 and 27.6 pods per plant respectively. This was followed by Biashara that produced a mean of 22.2 pods in a plant in Tharaka-nithi and 26.6 pods per plant in Meru. The local variety N26 produced the least number of pods per plant in both sites having a mean of 10.4 pods per plant in Tharaka-Nithi and 16.4 pods per plant in Meru.

Farmers' variety evaluation and selection

The following attributes were identified by the farmers as the most important when choosing green grams varieties; Early maturity, marketability, grain size, taste, non-stoniness, drought resistance, colour pest resistance, disease resistance. A pairwise ranking conducted revealed the most important attributes in order of importance when selecting the green gram varieties (Table 2). In Tharaka-Nithi early maturing (EM), resistant to diseases (RD) and drought tolerance (DR). In Meru the following attributes were considered by the farmers as important criteria of varieties selection: high yielding (YD), early maturity (EM), resistance to pests and diseases (RPD). With prioritized attributes, the varieties were chosen as follows: For Tharaka-Nithi, Karembo was ranked first followed by N26, Ndengu Biashara and Ndengu Tosha. In Meru Karembo similarly ranked first followed by Ndengu Tosha, Biashara and N26.

Table 2. Pairwise ranking of the desired attributes for green gram varieties in Tharaka-Nithi County

	EM	**MKT**	**GS**	**TA**	**NS**	**DR**	**CO**	**RD**	**RP**	**POINTS**	**RANK**
EM		EM	EM	EM	EM	EM	EM	EM	EM	8	1
MKT			MKT	MKT	MKT	DR	CO	RD	RP	3	6
GS				GS	GS	DR	CO	RD	RP	3	5
TA					TA	DR	CO	RD	RP	1	8
NS						DR	CO	RD	RP	0	9
DR							DR	DR	DR	6	**3**
CO								RD	RD	3	7
RD									RD	7	**2**
RP										4	4

Table 3. Pairwise ranking of the desired attributes for green grams varieties in Meru County

	SH	MKT	YD	EM	RPD	WC	TA	**POINTS**	**RANK**
SH		MKT	YD	EM	RPD	WC	TA	0	7
MKT			YD	EM	RPD	WC	TA	1	6
YD				YD	RPD	YD	YD	5	**1**
EM					EM	EM	EM	5	**2**
RPD						RPD	RPD	5	**3**
WC							WC	3	4
TA								2	5

DISCUSSION

Result indicated significance difference in the yield of different varieties with Karembo and Ndengu Biashara, attaining the highest yield in Tharaka-Nithi and Meru County respectively while the N 26 which was the control. The variation in yield could have been brought about by their genetic difference and also the ability to adopt in the environment since the managements practices were the same. Similarly Samant., (2014) reported that varietal difference and the environment may attribute the difference of plant growth in terms of plant height and the crop yield. The significance difference showed in the number of seed per pod between the varieties may have been attributed to different soil and elevation although the two area are arid and the genetic variability. Similar results were found by Uddin et al., (2009) who reported the differences in the number of seed per pod being attributed to the genetic variability and the bold large grain size of some varieties. The number of pods per plants was higher in the introduced new varieties than the existing N26 in the two Counties. These findings agreed with those of Rathod and Gawande (2014).

The attributes pointed out by the farmer groups such as early maturing, drought tolerance had similarly been reported by Karimi et al., (2019) about the same variety being a drought tolerant and early maturing varieties. It also explained that an early maturing variety is that variety that mature earlier than their local or the existing known variety. This is also supported by Mekbib (2006), who observed that the selection criteria of the variety were dictated by the Agro ecological zone and the variety the farmers know. Other attributes such as high yielding and tolerance to pests and diseases were also key in green gram variety selection and acceptance in Eastern Kenya. The same was agreeable with Itabari et al., (2004); Beebe et al., (2012) who reported that drought stress as the main cause for agricultural productivity in the Eastern region.

The farmers' evaluation on the varieties ranked N26 and Karembo as the best varieties in Tharaka-Nithi County and they had adapted well in the area. The results agree with Ceccarelli and Grando, (2007) that selection for specific varieties adaptation is important for the crop that predominantly do well in the existing areas with unfavourable environment.

CONCLUSION

The results in Meru and Tharaka-Nithi showed significant difference in yield among the green gram varieties. The local check (N26) recorded lower yields in both Tharaka-Nithi and Meru Counties. This clearly shows that the three new varieties were superior to the existing variety, locally known as nylon. Through participatory evaluation the most important attributes which included early maturity, high yielding, tolerance to pests and diseases and drought tolerance were a key for green gram productivity in the region. This widen the mind of the breeders on traits to consider when conducting breeding for green gram adaptation and acceptability considering that these attributes were as a result of the major challenge faced by farmers as they produced green grams. Acceptability of the new green gram varieties was an indication of increased varietal diversity in the market. With low rainfall early maturing varieties produced more than the existing variety that takes longer to mature. The new varieties could be classified as drought-escapers. The N26 requires higher rain as compared to the new varieties.

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