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Influence of Green Gram (*Vigna radiata* L.) Varieties on Growth and Yield Attributes in Dry Ecological Zones of Kenya

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Production and productivity of green gram is governed by environmental, genotypic trait of the crop and crop management. The more specific reason for low production and productivity of pulses is the cultivation of local old varieties under marginally fertile lands and low input management conditions. Recently, high yielding varieties of green gram have been developed and evaluation of these varieties under various management conditions will be of great importance. In this view the study was conducted to investigate the growth and yield response of different green gram varieties in Kitui and Makueni counties in Kenya. Three green gram varieties (KS20, KAT 00308 and KAT 00309) were laid out in a randomized complete block design and replicated three times. The varieties differed significantly ($P \leq 0.05$) in plant height, number of effective nodules, 100-grain mass and grain yield in both sites. Variety KS20 was the tallest in both sites in all the stages while KAT00309 was the shortest. Variety (KS20) had the highest number of effective nodules in Ithookwe (11) and Kiboko (39) with the lowest were recorded for variety KAT00308. Days to 50%

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flowering and maturity were different between the varieties, and KS20 had the shortest where it was recorded that the periods were shorter in Kiboko by >15 days compared to Ithookwe. In both sites, the highest grain yield was recorded for KAT00309 with 2898 kg/ha and 1568 kg/ha in Kiboko and Ithookwe, respectively. There were no signficant differences on the biological yield between the varieties but the 100-grain mass differed signficantly in both sites where variety KAT00309 was the heaviest with 7.8 g and 6.9 g in Kiboko and Ithookwe, respectively. It was concluded that variety KAT00309 could lead to the highest grain yield in both Kitui and Makueni counties under water stress conditions of the two counties.

Keywords: Green gram; productivity; varieties; effective nodules; yield.

1. INTRODUCTION

Production of green grams (*Vigna radiata* L.) is mainly (90%) situated in Asia with India producing the largest quantities (more than 50% of world production) and consuming almost its entire production. The main exporter of green grams is Thailand and had its production increase by 22% every year between 1980 and 2000 [1]. Its seed is more palatable, nutritive, digestible and nonflatulent than other pulses grown in the country. It is a good source of protein (20-24%), carbohydrates (60-62%), water (10%), fat (1.0%), 1.0-1.5% oil, fiber (4.0%), ash (3.0%) and by virtue of its nitrogen fixing ability, it plays vital role in sustaining soil fertility [2]. With sprouting there is an increase in the thiamine, niacin and ascorbic acid, thus green gram sprouts are increasingly becoming popular in certain vegetarian diets. Moreover, its food values lie in high and easily digestible protein. It is also a good source of mineral, pro-vitamin A, B complex and ascorbic acid. Amino acid analysis indicates that it is an excellent complement to rice for balanced human nutrition [2].

Green gram is a very important crop in the warm and dry parts of Eastern Kenya where it is grown for both subsistence and as a cash crop [3]. Dry grain is used for food, though in Asia where we have the largest number of people consuming green grams it is cooked as split grain. Mature green gram grains provide an invaluable source of digestible protein for humans in regions where meat is not available or where people are mostly vegetarian [3]. Green gram protein content varies from 21-29% based on the variety and environment where the crop was grown.

Green gram, being one of the most important pulse crops of Kenya, requires scrutiny of the varieties for their suitability under the existing agro- climatic conditions of the lower Eastern. Thus, it was important to identify their production potential in addition to their growth behavior, yield attributes, maturity period including seed yield per hectare under rain fed conditions. Even though green gram has a number of potential uses, the productivity of the crop in Kenya is very low under farmer's fields [3]. This is possibly due to lack of improved varieties for different environmental conditions, poor agronomic practices such as inappropriate use of seeding rate/plant density and variety selection. Green gram Production is constrained by several factors including poor soil fertility, inappropriate agronomic practices such as lesser or wider than optimal spacing and unsuitable varieties among others. Research on green grams in Kenya has been minimal but due to changing climate patterns and increasing global warming there is need for more research on green grams since it is one of the drought tolerant crops especially on varieties which do well in the lower Eastern part of Kenya where other crops like maize do not do very well.

2. MATERIALS AND METHODS

2.1 Study Areas

The study was carried out in two sites namely Kiboko in Makueni and Ithookwe in Kitui. At Kiboko, the experiment was carried out at the Kenya Agricultural and Livestock Research Organization (KALRO) centre-Kiboko. The site is located at 2°28'S, 37°83'E and 975 meters above sea level with an annual rainfall of 595 mm coming in two seasons and a mean annual temperature of 25.7°C. The site is in the dry low midland (LM) Zone V with soils that are generally low in organic matter (0.1-0.5% C content), thus highly vulnerable to degradation through physical erosion as well as chemical and biological degradation. The Ithookwe site is located at 1°37'S, 38°02' E and 1160 meters above sea level with an annual rainfall of 1080 mm coming in two seasons and a mean annual temperature of 22.5°C. The site is in Lower Midland (LM) to

Upper Midland (UM) Zone III to IV with soils that are sandy clay loam [4].

2.2 Experimental Design and Treatments

The experiment was carried out during the October – December short rains of 2016. The treatments comprised: three green gram varieties (KS20, KAT 00308 and KAT 00309). These treatments were laid out in a randomized complete block design and replicated three times. The experimental plot size was 1.35 m x 3 m with spacing of 1 m between plots and 2 m between blocks.

2.3 Cultural Operations

The field was ploughed and prepared to a fine tilth and pegged to divide it into three blocks made up of 30 plots of four rows each. Planting was done in moist soils on 4th of November 2016 in Ithookwe and 17th of November 2016 in Kiboko with two seeds planted per hole in 45 cm spaced rows in both sites. Seedlings were thinned to have one plant per hole. The experimental field was kept weed free throughout the growth period by manual weeding. No fertilizer application was done in both sites because soil phosphorous (P) and Potassium (K) were adequate while N and all other deficient nutrients were applied uniformly. All other land management practices were done uniformly across the treatments.

2.4 Data Collection and Analysis

Growth parameters, phenological aspects, yield and yield components were determined with harvesting being done on 7th January 2017 in Ithookwe and on the 24th January 2017 in Kiboko. Plant height was determined at 21 DAS (Days after Sowing) and fortnightly up to pod stage and the average value of plant height from each plot was computed. Three areas of 0.25 m^2 were randomly selected in each plot and a square dowel (50 cm x50 cm) used to estimate the % ground cover in each of the selected 0.25 m^2 areas at 21 DAS and fortnightly up to pod stage. Average % ground cover per plot was recorded. The grain produced from a randomly selected 1m^2 area (net plot) in each plot was harvested and recorded separately. The grain yield per m^2 was then converted into kilograms per hectare (kg ha^{-1}). The data collected was refined, tabulated and subjected to Two-Way Analysis Of Variance (ANOVA) using Statistical Analysis System (SAS) to test significance. The means were separated using Fisher's Least Significance Difference (LSD) at 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Plant Height and Number of Effective Nodules

The varieties differed significantly (P≤0.05) in both sites on height at all the sampling stages from 3 to 7 weeks after sowing (Table 1). The tallest variety in Kiboko was KS20 while KAT00309 was the shortest. In Ithookwe, KS20 was the tallest at all the sampling stages with the other two varieties interchangeably showing shorter stature (Table 1).

Variety KS20 was superior to the other varieties on most of the growth parameters viz plant height and shoot dry weight. Fully yielding ability of a variety could be realized if grown under suitable environmental conditions with adoption of suitable management practices [5]. The yield of a crop is result of the proper manifestation of the growth and development activities in individual plants, which in turn, would depend upon genetic potential of the variety and the environmental condition. Real potential of the variety could be exploited to its maximum with several agronomic manipulations which alter the

Table 1. Plant height of different green gram varieties in Kiboko and Ithookwe at 3, 5 and 7 weeks after sowing

Variety	Kiboko			Ithookwe		
	3 WAS	5 WAS	7 WAS	3 WAS	5 WAS	7 WAS
KAT00308	10.0b	28.3b	55.1a	8.8b	17.7b	30.4b
KAT00309	9.6b	27.9b	52.2b	9.1b	17.4b	29.2b
KS20	13.0a	32.6a	55.3a	11.4a	20.2a	33.7a
LSD	0.545	1.061	2.522	0.903	2.906	2.906
P value	<.001	<.001	0.031	<.001	0.016	0.004

Means followed by different letters in a column are significantly different at 95% confidence level, WAS-Weeks after Sowing

Table 2. Influence of varieties on the number of effective nodules of green gram in Kiboko and Ithookwe at 3, 5 and 7 weeks after sowing

Variety	Kiboko			Ithookwe		
	3 WAS	5 WAS	7 WAS	3 WAS	5 WAS	7 WAS
KAT00308	13c	19b	11b	1b	3b	2b
KAT00309	18b	25b	13b	2b	5b	4b
KS20	29a	39a	23a	4a	11a	8a
LSD	3.884	4.333	4.334	1.147	2.778	1.846
P value	<.001	<.001	<.001	<.001	<.001	<.001

Means followed by different letters in a column are significantly different at 95% confidence level, WAS-Weeks after Sowing

micro-environment of a crop. Yet, whole plant growth and competitive ability depends not only on the photosynthetic rate of individual leaves, but also on the geometry and dynamics of a plant's canopy and the pattern of energy all Cation among all organs [6].

There were signficant differences (P≤0.05) between the varieties on the number of effective nodules in Kiboko and Ithookwe (Table 2). The highest number of nodules in Kiboko and Ithookwe was observed on variety KS20 while the lowest was on variety KAT00308.

Variety KS20 had the highest number of effective nodules per plant and this can be supported by the correlation where it was observed that increase in the plant height and shoot weight was positively correlated with the number of nodules. Nodulation is an important character of crop which is directly related with the number of pods formation per plant and ultimately the productivity of crop [7]. Variation in the phenological parameters among the varieties of green gram reflects the fact that there were wide differences in the duration of vegetative growth, thereby duration in the reproductive phase which are genetically controlled. Such type of variability is likely to persist with the effort of genetic advancement for acquiring desirable traits with the existing parent materials. The variation in phenological parameters among the varieties have been reported by Mathu et al. [8].

3.2 Flowering and Maturity

The days to 50% flowering differed significantly (P≤0.05) between the varieties of green gram (Table 3). The period to 50% flowering was shortest on varieties KAT00309 and KS20 at Kiboko while in Ithookwe there were no differences between the days to 50% flowering. The days to maturity were significantly different in both sites where KS20 variety had the shortest period to maturity (58 days) compared to the other varieties in Kiboko. The period to maturity in Ithookwe was longer compared to that of Kiboko where variety KAT00309 had the shortest period while KAT00308 had the longest.

The interaction between environmental factors and the green gram plant, such as the efficiency of a green gram cultivar in fixing atmospheric nitrogen; climatic factors (temperature and photoperiod) and bacterial strain competitiveness, the amount and the quality of the inoculant directly influenced the days to flowering and maturation of green gram varieties in both sites as also reported by ERA [9].

3.3 Yield and Yield Components

The 100-grain mass and grain yield were significantly (P≤0.05) influenced by varietal differences in both sites. However, the difference in the biological yield was not significant due to varietal differences in both sites (Table 4). The highest grain yield of green gram (2898 kg/ha) was observed on variety KAT00309 in Kiboko which was not significantly different from that on variety KAT00308 (2618 kg/ha) while the lowest was on variety KS20. In Ithookwe, the highest grain yield was recorded on variety KAT00309 (1568 kg/ha) which did not differ significantly from that of variety KS20 with the lowest exhibited on variety KAT00308. The differences on the 100-grain mass of green gram was significant between the varieties where the highest was on variety KAT00309 in Kiboko and Ithookwe with 7.8 g and 6.9 g respectively while the lowest was observed on variety KS20 with 6.9 g and 5.9 g respectively.

Such a wide variation in the productivity parameters among the different green gram varieties have also been observed by many research workers like, Singh et al. [10]. Kabir [11] in his study with mungbean showed that the highest 1000 seeds weight was obtained when large sized seeds were sown. Similar result was

Table 3. Varietal differences on the days to 50% flowering and maturity of green gram in Ithookwe and Kiboko

Variety	Kiboko		Ithookwe	
	Days to 50% flowering	Days to maturity	Days to 50% flowering	Days to maturity
KAT00308	36a	59a	41a	72a
KAT00309	35b	59a	41a	70c
KS20	35b	58b	41a	71b
LSD	0.51	0.1497	0.775	0.847
P value	0.017	<.001	0.987	<.001

Means followed by different letters in a column are significantly different at 95% confidence level, WAS-Weeks after Sowing

Table 4. Varietal differences on the biological yield, 100-grain weight and grain yield of green gram in Kiboko and Ithookwe

Variety	Kiboko			Ithookwe		
	Biological yield kg/ha	100-Grain weight	Yield Kg/ha	Biological yield kg/ha	100-Grain weight	Yield Kg/ha
KAT00308	5924a	7.399b	2618ab	4003a	6.40b	1404b
KAT00309	6119a	7.833a	2898a	3982a	6.88a	1568a
KS20	5907a	6.943c	2506b	4047a	5.90c	1429ab
LSD	354.1	0.2353	170.1	627.3	0.306	149.7
P value	0.416	<.001	<.001	0.985	<.001	0.032

Means followed by different letters in a column are significantly different at 95% confidence level

also obtained by Islam [12] who worked with mungbean. The wide differences among the green gram varieties with respect to branches formation may be owing to inheritance of genetic divergence of the varieties. The present findings have been supported by many workers [13,14].

Pedersen [15], in mungbean, reported that smaller and larger seeds of same variety will have the same yield potential. Gan et al. [16] postulated that seed size had no significant impact on plant growth, development and seed yield of large-seeded crops such as chickpeas. However, in other crops, Stougaard and Xue [17] reported that the use of higher larger seed sizes improved yields by 18%, and the use of small seeds reduced yield by 16% in wheat. This was also reported by Royo et al. [18]. In chickpea and lentil, it was observed that plants from large seeds yielded 6% more than medium seeds and 10% more than mixed seeds [19].

4. CONCLUSION

The varieties differed significantly in growth, nodulation and yield parameters in both sites. Variety K20 being superior on the basis of growth and nodulation than the other varieties. Variety KAT00309 ranked first in terms of highest grain yield. Therefore, it is recommended that Variety KAT00309 be grown in Makueni and Kitui counties for the potential grain yield of green gram to be attained.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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