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Full Length Research Paper

Yield components of six pearl millet (*Pennisetum Glaucum* (L.)R. Br) varieties in the arid South Eastern part of Kenya

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In Africa, cultivation and consumption of cereal crops is widespread. Erratic, unreliable rainfall and frequent droughts have resulted in drastic decline of world cereal yields and agricultural production. Pearl millet [*Pennisetum glaucum* (*L.*) R. Br.] is a potential crop for the semi-arid Kitui County, but there are few studies on production practices .Most farmers tend to prefer local varieties over hybrids owing to greater risks of crop failure.Development of early maturing elite pearl millet varieties with farmer preffered traits and adapted to drought stress is very significant and relevant for plant breeding.Poor adoption of improved hybrid pearl millet*(Pennisetum glaucum)* in the semi arid zone of South Eastern Kenya has been attributed to the lack of early maturing hybrids with high production potential.The objective of this research was to determine the growth parameters for pearl millet in this zone. This would optimize pearl millet yields, thus increasing the prospect for pearl millet as a cereal crop. This experiment was conducted with six pearl millet varieties raised in a completely randomized design with three replications at South Eastern Kenya University research and demonstration farm.General mean performance of the six pearl millet genotypes revealed significant differences(p<0.05) for days to emergence, days to anthesis, days to 50% flowering and days to 50% maturity. It also showed that millet varieties were superior in plant characters such as days to emergence, days to anthesis, days to 50% flowering and days to 50% maturity.The early maturing group included Pvs-pm 1005 (66.1 days to 50% maturity) and Pvs-pm 1006(74.22 days) while the local landrace (Kimbeere) took the longest time (80.33 days) to mature over the three cropping seasons.These preliminary results have clearly shown the superiority of Pvs-pm 1005 and Pvs-Pm 1006 compared to the widely grown but very old local farmer variety Kimbeere.This trial is a confirmation that current hybrids offer farmers more advantage over their traditional landraces even when under well managed rainfed arid zone environments.

Keywords: Pearl millet, emergence, flowering, maturity, landraces.

INTRODUCTION

Pearl millet is a globally cultivated cereal, unique due to its tolerance to drought, low pH, low soil fertility and high temperatures (Ntare, 1990; Hajor et al., 1996). In fact it is the only suitable and efficient crop for arid and semi arid conditions because of its efficient utilization of soil moisture, high level of heat tolerance and low fertility than sorghum and maize (Shah et al., 2012). It is by far the most important millet in Africa and worldwide (Polaszek et al., 1998; ICRISAT/FAO, 1996). Due to its tolerance, pearl millet can be grown in areas where other cereal crops such as maize and wheat would not survive (Basavaraj et al., 2010) and can yield in areas that receive rainfall as low as 200 to 250mm (Bidinger and Hash, 2003).

Pearl millet *(Pennisetum glaucum* (L) R. Br.) is an overlooked and underutilized traditional dryland crop in the drier parts of Arid and Semi-Arid areas (Obilana, 2003). The main challenges for farmers within the semi-arid and arid tropics and sub-tropics are food insecurity, risk of crop failure and yield instability (CCN Kenya, 2013).These areas are characterized by erratic, unreliable rainfall and sandy soils with low fertility (Kasei,2001; Krogh, 1997; Gandah et al., 2003), where other coarse cereals such as sorghum and maize fail to produce assured yields (Basavaraj et al., 2010; FAO and ICRISAT, 1996).The crop is grown by millions of resource-poor, subsistence level farmers (IFAD, 1999).

Change of weather patterns around the world are leading farmers to consider shifting crops, particularly to varieties that are resistant to worsening droughts, floods and high temperatures (Njagi, 2012).Therefore, the need for more drought resistant and early maturing varieties of dryland crops like pearl millet is very important to increase production and utilization in the ASALs (CGIAR, 2011).

A major problem of rain-fed agriculture in semi-arid regions with short rainy seasons is how to determine the maturity period. Previous work has however not evaluated the effect of maturity dates on performance of these improved varieties. Date of maturity directly affects the length of the growing season, varieties of different maturity groups will correspondingly be affected.The current study was therefore undertaken to determine the maturity date on pearl millet varieties of different maturity groups.

Development and cultivation of improved farmer-preferred cultivars with specific adaptation to the environments, pearl millet can significantly contribute to food security in Africa and the world at large (CGIAR, 2011). This will overcome Africa's stagnant dryland food production trends and growth (CGIAR consortium, 2011). The area where pearl millet is important in ECA falls within low agricultural potential, low market access, and low population density production domain according to Omamo et al (2006).These areas include some lowland areas of Eritrea, Ethiopia, Western and Northern Sudan, Eastern Kenya and the central plateau of Tanzania (Omamo et al.,2006).

In most crops, matching plant phenology with the stress environment is a key factor in adaptation to drought.Eastin and Sullivan (1974) developed simple developmental stage terminology useful for yield and yield component analyses for grain sorghum on the basis of growth stage as follows: (i) the vegetative period from planting to panicle initiation (GS1);(ii) the reproductive period (GS2) from panicle initiation to flowering; and(iii) grain period (GS3) from flowering to physiological maturity.These three developmental stages were similarly described for pearl millet by Maiti and Bidinger (1981). For grain sorghum and pearl millet, potential kernel number is set during GS2 and kernel weight is determined within genetic limits during GS3 (Eastin et al., 1999; Maiti and Bidinger, 1981).

Drought avoidance in pearl millet has resulted in a large range of maturity types, selected by farmers and breeders to match the crop phenology to the average water supply of the environment(Bourke,1963). Secondly, drought avoidance can be achieved by varying the duration of growth perid depending on the extent of water deficits,a characteristic currently known as 'development plasticity'(Ludlow and Muchow,1988).

MATERIALS AND METHODS

Description of experimental site

Varietal performance trial was conducted at South Eastern Kenya University main campus research farm to select the best performing varieties with respect to yield components.The SEKU site is located at Kwa Vonza division in the Lower Yatta, Kitui County, 17 Kilometers off Kwa Vonza Market, along the Kitui-Machakos main road. This area is in eco-zone V (Jaetzold and Schmidt 1983). This area is a semi-arid zone with the annual rainfall amount ranging between 400mm-800mm, temperature range is between 14^0 C- 34^0 C latitude 1^0 22 57 S, longitude 38^0 00 19 E and 1152m above sea level. The soil type of the study area are predominantly sandy to loamy sand textureThis makes them tsusceptible to erosion and limited capacity to retain water and nutrients. The soils are generally poorly drained and easily eroded by runoff (Borst & De Haas, 2006).The area is mainly dominated by crop andLivestock mixed farming system comprising non legumes ,legumes and fruits. ,

Description of the experimental materals

Plant materials

The material required for the trial was collected from ICRISAT which consisted of six pearl millet varieties Pvs-Pm 1005, Pvs-Pm 1006, Pvs-Pm 1002, Pvs-Pm 1003, Pvs-Pm 1004 and Kimbeere (local variety).

Experimental design

The trial experiment was conducted in a completely radomized design with three replications and a gross plot size of 41m long and 15.75m wide. The plot size of each variety was 5m long and 5.25m wide. The experimental site was thoroughly ploughed and harrowed using a tractor. Levelling of the land was done provide a medium fine tilth seedbed for the growth of the crops.Alley ways were created between the replicates of width 1m. Sowing was done at spacing of 75cm between rows by drill between plants. After two weeks of germination the plants were thinned to intra row spacing of 30 cm Weeds were managed by hand weeding after weed emergence and late-emerging weeds were also removed by hand hoeing to avoid competition for nutrients.

Data collection

Data collection and observations were done on the net plot from three inner rows on the following yield components according to Izge *et al. (*2005) and Nwasike *et al. (*1992). Five yield components recorded were:

- Days to emergence
- Days to anthesis(DTA): Number of days from planting to the date when the first flower opens.
- Days to 50% flowering(DFF) – This was taken by counting the number of days from planting to when half the plants in a plot reached 50% stigma emergence
- Days to 50 % Maturity: Number of days from planting to the date when 50 % of the net plot plants had physiological maturity.
- Spike length

Statistical analysis

Analysis of variance (ANOVA) was conducted for several crop parameters and mean values were reported. Duncan's multiple range test was used to determine significant differences between means at the level of $P < 0.05$.The data data was statistically analyzed using the Genstat 15^{th} Edition (VSN-International, 2012).

RESULTS AND DISCUSSIONS

General mean performance of the six pearl millet genotypes are shown in (Table 1) The results of trial revealed significant differences ($p<0.05$) for days to emergence, days to anthesis, days to 50% flowering and days to 50% maturity. It also showed that hybrid millet varieties were superior in plant characters such as days to emergence, days to anthesis, days to 50% flowering and days to 50% maturity.

Table 1: Mean performance of six pearl millet genotypes for days to emergence, days to anthesis, days to 50% flowering and 50% maturity across 2012, 2013 and 2015 rainy cropping seasons.

	Season 1				**Season 2**				**Season 3**			
Varieties	DTE	DTA	DTF	DTM	DTE	DTA	DTF	DTM	DTE	DTA	DTF	DTM
Pvs-Pm 1005	6.0_{c}	38.7_{bc}	50.7_{bc}	70.7_{b}	3.3_{a}	33.3_{ab}	42.0_{a}	64.7_{a}	3.3_{a}	31.7_{a}	43.7_{a}	64.0_{a}
Pvs-Pm 1006	6.0_{c}	44.3_{cdef}	56.3_{efgh}	76.3_{cde}	4.0_{a}	38.7_{bc}	48.0_{b}	72.7_{bc}	4.0_{a}	39.0_{bc}	51.0_{bcd}	73.7_{bc}
Pvs-Pm 1002	6.3_{cd}	45.3_{def}	57.0_{efgh}	77.0_{cde}	3.3_{a}	38.3_{bc}	50.7_{bc}	74.0_{bcd}	3.3_{a}	42.0_{cde}	53.3_{cde}	74.0_{bcd}
Pvs-Pm 1003	7.0_{de}	47.0_{ef}	59.0_{gh}	79.7_{de}	3.7_{a}	43.3_{cdef}	55.3_{efg}	76.0^{bcd}	4.0_{a}	42.7_{cdef}	54.7_{cdef}	74.7_{bcd}
Pvs-Pm 1004	7.0_{de}	45.7_{def}	57.7_{fgh}	82.7_{ef}	5.0_{b}	40.0_{cd}	55.3_{efg}	77.0_{cde}	3.7_{a}	43.0_{cdef}	55.0_{defg}	75.3_{bcd}
Kimbeere	7.3_{e}	48.3_{f}	60.3_{h}	86.0_{f}	5.0_{b}	45.3_{def}	57.3_{efgh}	77.7_{cde}	3.7_{a}	44.0_{cdef}	56.0_{efg}	77.3_{cde}
LSD	0.4	5.2	3.70	4.7	0.4	5.2	3.7	4.7	0.4	5.2	3.7	4.7

DTE-Days to emergence, DTA-Days to anthesis, DTF-Days to 50% flowering, DTM-Days to 50% maturity. Values followed by the same subscript letters in the same column are significantly different ($P<0.05$) from each other at 5% level according to ANOVA protected LSD test.

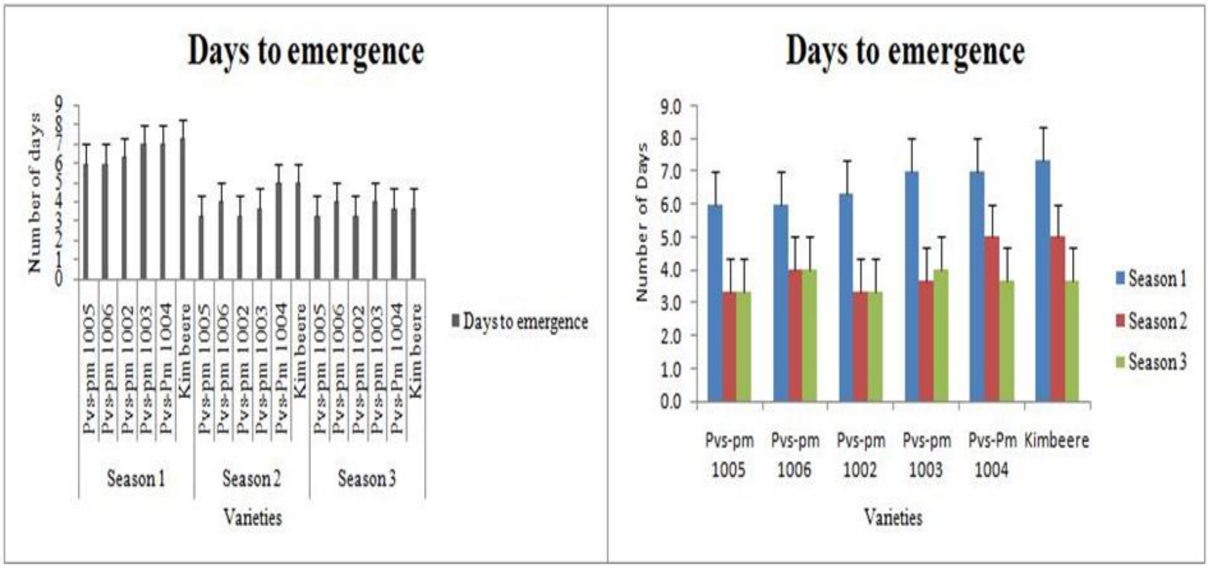

Figure 1: Days to emergence of six pearl millet varieties over the three cropping seasons (2012, 2013 and 2015 cropping seasons).

The existence of relationships between start, end and length of growing season, and number of wet days per growing season is critical for planning farming activities before the start and during the season (Mugalavai et al., 2008). As pearl millet is largely a quantitative short day plant, flowering early can result to changes in yield relative to day length (Mangat et al., 1999).Time required to reach 50% flowering influences pearl millet grain yield being associated with longer days to attainment of 50% flowering.This could be due to longer periods of utilization of plant growth resources such as nutrients, soil moisture and solar radiation.

Days to emergence

The results below (Figure 1) shows that days to emergence was significantly ($p<0.05$) different across all the 6 pearl millet genotypes. Kimbeere recorded significantly more number of days to emergence (5.3 days) compared to other five genotypes. The trend on days to emergence across the three seasons was significantly ($p<0.05$) different from each other with season 1 (2012) recording more mean days to emergence (6.6 days) compared to season two (4.1 days) and three (3.7 days).The trend in the number of days to emergence in all the three season reveal that Pvs-Pm 1005 recorded less days (4.2 days) while Kimbeere recorded the longest number of days to emerge (5.3 days) in all the three seasons (Figure 1).One of the most important cultural techniques of pearl millet is to encourage rapid and uniform emergence of seedlings to establish good stand and to let them grow well.

Days to anthesis

Results for days to anthesis were significantly different ($p<0.05$) among the six pearl millet varieties over the three cropping seasons (Figure 2). Kimbeere recorded significantly ($p<0.05$) more days (45.9 days) compared to other 5 genotypes of pearl millet variety while it was Pvs-Pm 1005 that recorded significantly

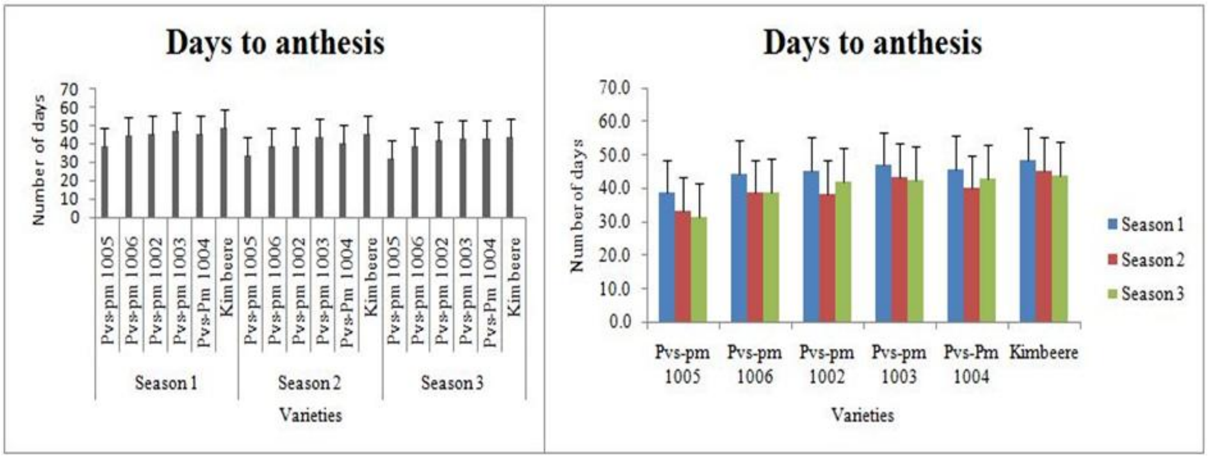

Figure 2:Days to anthesis of the six pearl millet varieties over three rainy cropping seasons (2012, 2013 and 2015)

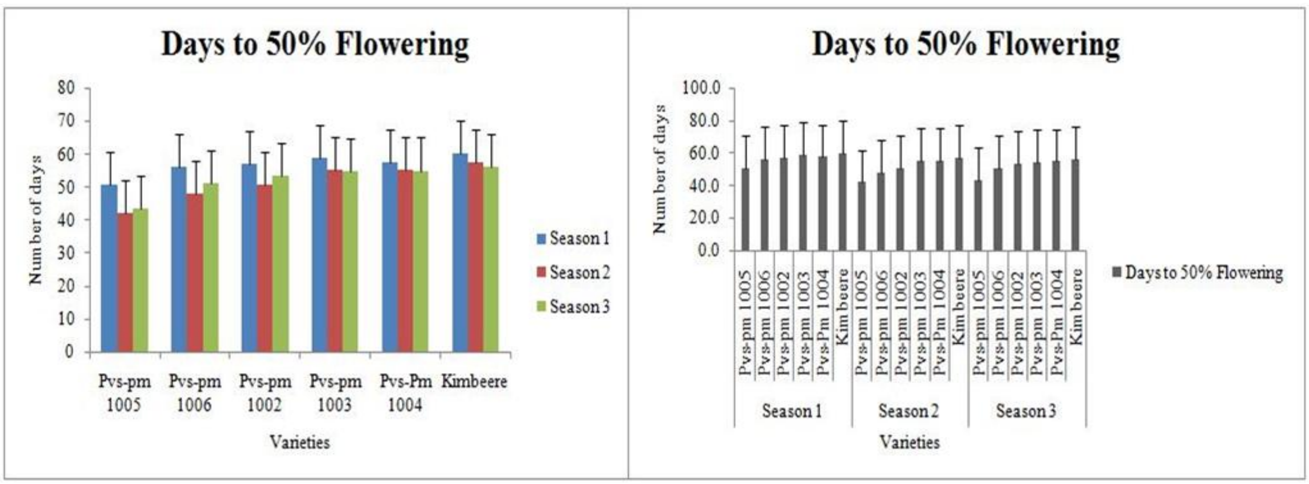

Figure 3: Days to 50% flowering of six pearl millet varieties over the three rainy cropping seasons (2012, 2013 and 2015)

($p<0.05$) less days to anthesis compared to other pearl millet varieties (Figure 2).Season 1 recorded significantly ($p<0.05$) more mean days to anthesis (44.9 days) compared to season 2 and 3 which recorded 39.9 and 40.4 days.

Days to 50% Flowering

The plants were monitored daily and the number of days taken in each plot for 50% of the millet plants to flower recorded. Days to 50% booting/flowering among the six pearl millet genotypes was significantly different ($p<0.05$) as shown in (Figure 3) The number of days to 50% booting ranged between 46 and 56 days (Figure 3). The average days to flowering were 54.2 days. This is an indication that the seasonal rainfall distribution affected days to 50% flowering among millet varieties.

The results on the number of days to 50% flowering show that late maturing varieties having longer period of growth yield more.Similar results have been reported by

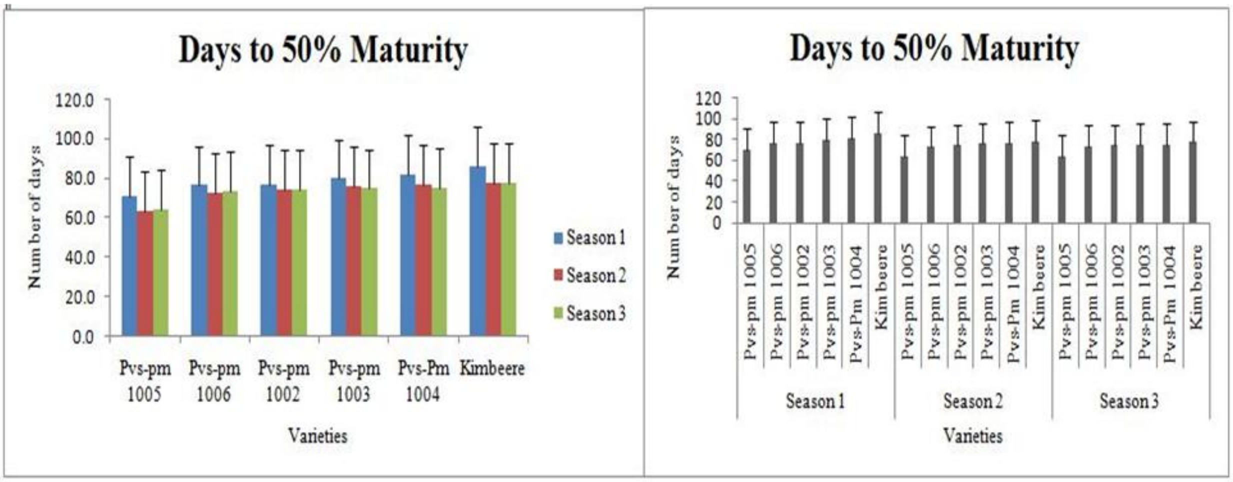

Figure 4: Days to 50% maturity of six millet genotypes over 2012, 2013 and 2015 rainy cropping season

Tominilia (1975), who reported that the later ripening millet varieties gave the highest grain yield.Begg and Burton(1973), from a study on comparison of five genotypes of bulrush millet,reported that the late maturing inbred and the F_1 hybrids gave higher dry matter indicating there suitability for development as forage types for use in ASAL regions. Flowering time, a so-called “drought escape mechanism,” is the major component of pearl millet’s adaptation to water-scarce environ- ments (e.g., Bidinger et al., 1987a,).Early and asynchronous development of panicles and flowers has the potential to spread flowering over a long period, maintaining the yield potential even if the stem is demaged(Mahalakshmi et al., 1987)

Days to 50% Maturity

Results for days to 50% maturity are summarized in Figure 4. Significant differences in days to 50% maturity (P<0.05) were observed among pearl millet genotypes in all the three seasons..The mean for days to 50% maturity for all the genotypes was 75.07. Pvs-Pm 1005 was relatively early and attained 50% maturity at 66.1 days followed by Pvs-Pm 1006,while Kimbeere attained 50% maturity at 80.33 days.There were no differences in days to 50% Maturity between genotypes and seasons. Similar results have been reported by muhammed et al (2002).

Spike Length

Panicle length and structure is an important agronomic trait in the acceptance of variety by farmers in arid and semi-arid regions of Africa (Ouendeba et al., 1996). Most pearl millet cultuvars are characterized by short and compact panicles.The panicle length for most genotypes was significant(P<0.05).This study found that the farmer variety has the shortest panicle among the six genotypes and Pvs- Pm 1006 as having the longest panicle.Good potentials also exist for Pvs-Pm 1005,Pvs-Pm 1002, Pvs-Pm 1003 and Pvs-Pm 1004 for production of longer panicle length(Figure 5). They can further be subjected to selection for improved panicle length.Ouendeba *et al.*(1996) reported that farmers were found to select seeds based on spike length, spike compactness and seed size for susequent planting. Comperative perfomance of the hybrids clearly potrayed their superiority over the farmer local variety.

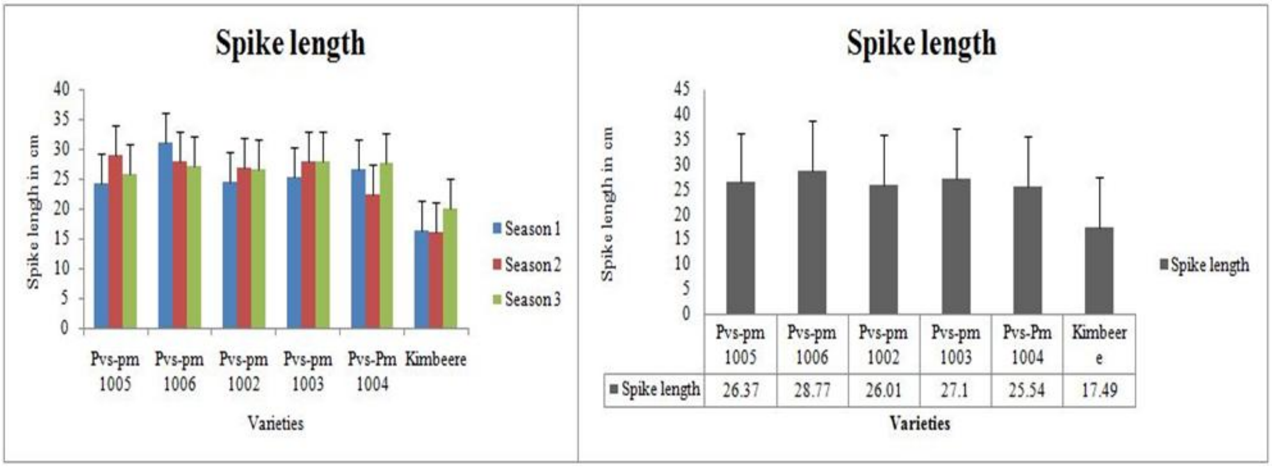

Figure 5: Spike length of six pearl millet varieties during the three rainy cropping seasons (2012, 2013 and 2015) rainy cropping season

CONCLUSION AND RECOMMENDATIONS

The study has clearly shown the superiority of Pvs-pm 1005 and Pvs-pm 1006 compared to the widely grown but very old improved pearl millet variety Kimbeere. Therefore, the early maturing varieties (Pvs-pm 1005 and Pvs-pm 1006) can be considered for general cultivation under the agro-climatic conditions of semi-arid South Eastern Kenya.This is a confirmation that even under well managed,but rainfed,arid zone environments,current hybrids offer farmers more advantage over their traditional landraces.Therefore, there is need to breed for early maturity in the local farmer variety which recorded relatively long maturity periods over the three cropping seasons. The two varieties (Pvs-pm 1005 and Pvs-pm 1006) can be released to farmers in order to increase both yields and areas of cultivation of the crop, which has lost grounds to maize cultivation in recent times due to the lack of improved early maturing and yielding varieties.

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