

ORIGINAL RESEARCH

Agronomic evaluation of seedbed and mulching alternatives with plant spacing for dry-season fluted pumpkin in coarse-textured tropical soil

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Abstract

Fluted pumpkin (*Telfairia occidentalis*) has high agronomic and food relevance in the tropics. Production of this vegetable in the dry season with irrigation is increasingly popular and is mostly on droughty soils, thus requiring research on appropriate combination of soil moisture conservation/management practices. This study evaluated the interactions among seedbed configuration (flat and raised), surface mulching (grass-mulched and no-mulch) and plant spacing (100², 50² and 25² cm², designated wide, intermediate and close spacing, respectively) on fluted pumpkin performance in a sandy-loam soil in southeastern Nigeria during 2014/2015 dry season. Seedling emergence (ratio of emerged to expected seedlings) was highest and lowest in flat/mulched/wide and flat/no-mulch/close combinations, respectively. Main effects showed higher seedling emergence in mulched (67.9%) than no-mulch plots (53.1%) and in wide (70.8%) and intermediate spacing (64.6%) compared to close spacing (46.0%). Fresh leaf yield assessed biweekly during 6–14 weeks after sowing was generally highest and lowest in flat/mulched/close and flat/no-mulch/wide combinations, respectively. Seedbed configuration had no distinct effect on leaf yield; hence, flat/mulched/close option was similar to raised/mulched/close option. Yields from mulched/wide and no-mulch/close options were similar with a mean (2735 kg/ha) approximating the overall mean (2868 kg/ha). Flat/mulched/close combination is the best management practice to grow fluted pumpkin with irrigation on droughty soils during the dry season of the tropics. Where this best practice is compromised due to mulch or seed scarcity, the ensuing no-mulch/close and mulched/wide, respectively can support dry-season production of pumpkin in droughty tropical soils at average levels.

Introduction

Among the vegetable crops that are indigenous to the tropical Africa, fluted pumpkin (*Telfairia occidentalis* Hook F.) is the most cultivated in the region mainly in south-eastern Nigeria owing to its edible succulent shoots and leaves. This vegetable is widely eaten, serving as a vital vegetable supplement in the carbohydrate-dominated diet of the people. The tender vines, leaves and seeds are

consumed by humans, whereas the mature vines are an important fiber source in animal diet. Today, fluted pumpkin is cultivated in almost all parts of tropical Africa not only as backyard crop but also as commercial crop during the rainy and dry seasons of the region.

Fluted pumpkin is a rich source of protein, oil, vitamins and minerals (Aregheore 2007; Nwite et al. 2013). This vegetable has also gained medicinal recognition as blood purifiers (Aletor et al. 2002), and as food supplement to

maintain good health among resource-poor farmers in developing countries.

Research has shown that some production techniques could affect fluted pumpkin yield. These include time of sowing (Asiegbo 1985), tillage practice (Awodun 2007a), manure rate (Ogar and Asiegbo 2005; Awodun 2007b), plant staking (Egun 2007; Chukwudi and Agbo 2013), and cutting frequency (Ogar and Asiegbo 2005; Chukwudi and Agbo 2013). In Nigerian savanna where bulk of agriculture is done, low status of plant nutrients and poor soil physical condition constitute serious agronomic constraints (Salako 2003). For the low soil fertility, combined use of organic amendments and inorganic fertilizers to improve productivity of fluted pumpkin has been advocated (Ndor and Dauda 2013; Iren et al. 2014). The use of organic amendments (poultry droppings) alone has also been found to be effective for fluted pumpkin particularly in acid Ultisols of the Nigeria savanna (Ndor and Dauda 2013; Nwite et al. 2013).

The problem of poor soil physical condition for fluted pumpkin could also be ameliorated by right combination of organic and inorganic fertilizers (Nwite et al. 2012). One major factor still lowering the crop's productivity in tropical Africa is disregarding this vegetable as major crop during the rainy farming season in the region. Hence, it is often grown with residual soil moisture and manual irrigation in the dry season.

Considering the crop's role in food and nutrition security, its skeletal production in the rainy season needs to be expanded into the dry season of the tropics using viable resource management practices. Fluted pumpkin is known to prefer a loose, friable soil with ample humus and shade (Olaniyi and Odedere 2009). Although the crop is also known for drought tolerance, its productivity might be increased with appropriate seedbed-mulch combination to enhance moisture storage in the root zone while adopting the plant density that could provide adequate protective cover and optimize resource use.

Seedbed configuration plays an important role in conservation of soil water. Raised seedbed systems have been used since time immemorial by farmers in many parts of the world (Govaerts et al. 2007). Their use has traditionally been linked with water management issues; to drain the cropped farmland of excess water or to irrigate crops via furrows in semi-arid and arid regions (Sayre 2004). Flat seedbeds are also commonly used in crop production but they offer smaller inducement to rooting and drainage, and this often makes for poorly structured soil. Such conditions deter the establishment of adequate protective crop cover early in the season. Narkhede et al. (2015) reported that opening of furrows between rows increased the growth and yield attributes of cotton (*Gossypium* spp.) compared to flatbed sowing.

Mulching is also an important soil and water management practice in dry season farming. The many benefits

of surface mulch to the soil and the crop grown therein are well known, including maintenance of uniformly high soil water status thus reducing irrigation frequency especially in dry season production (Obalum et al. 2011a). Odiaka et al. (2008) noted that in Nigeria fluted pumpkin is not commonly grown with mulch as the crop is assumed to adequately cover the soil. Nevertheless, this concept can be contested for the droughty soils of the savanna zones. In the present location at Nsukka, for instance, surface mulch was found to increase the yield of soybean (*Glycine max* M.) that provided cover to the soil, and this was even under rainfed conditions (Obalum et al. 2011b). There have been similar reports of mulch-induced increases in fresh and dry weights of vegetables including fluted pumpkin (Okugie and Ossom 1988; Mahadeen 2014; Aniekwe 2015).

Furthermore, the practice of adopting a plant spacing that gives the desired plant density for simultaneously conserving resources and optimizing crop yield is an important factor in agronomic production. Improper plant spacing may cause either too dense or too sparse a population resulting in reduced yield, whereas optimum plant density ensures efficient use of resources to give maximum yield. Some researchers have reported increased above-ground yield of vegetable crops at close spacing (Firoz et al. 2009; Uko et al. 2013). In Nigeria, fluted pumpkin is traditionally spaced 100 cm × 100 cm (Nwite et al. 2013), but this is deemed too wide especially under conditions of limiting soil water in the dry season.

The trio of seedbed configuration, surface mulch and plant spacing on a droughty soil in a tropical environment is thought to produce interaction effect on performance of dry-season fluted pumpkin, but this has yet been reported. This hypothesis was therefore tested in the dry season on a coarse-textured soil at Nsukka in southeastern Nigeria with the crop's performance indexed by seedling emergence and by periodic fresh leaf yield.

Materials and Methods

Study area

The experiment was conducted at the University of Nigeria Teaching & Research Farm, Nsukka, located at 06°52'N, 07°24'E. The site is on an altitude of approximately 400 m above sea level. Nsukka has a tropical humid climate characterized by the existence of two distinct seasons; the rainy season (April–October) and the dry season (November–March). The study was done during the 2014/2015 dry season. Mean annual total rainfall is about 1600 mm with the mean annual evapotranspiration often exceeding this value in recent years. Temperature is uniformly high all-year-round, with mean minimum and

maximum annual values of 21°C and 31°C, respectively, though the latter can approach 35°C during the hottest months. Rarely does the relative humidity fall outside the range 55–80% throughout the year.

The soil at the experimental site, derived from false-bedded sandstones, is deeply weathered, brownish red in color, coarse-textured, excessively porous and well drained. The soil is classified as Acrisol by the World Reference Base for Soil Resources (IUSS Working Group 2006). Soil moisture is usually recharged with the onset of rains and sometimes there can be moisture surplus of about 260 mm at the peak of the rainy season, which depletes to a mean deficit of 650 mm in the dry season (Mbagwu 1987). Within the control section, the soil has an ustic moisture regime and an isohyperthermic thermal regime. The prevailing vegetation is grassland typifying the area as derived savanna in southeastern Nigeria.

Field study

The field study was sited some 40 m away from where a similar study with information on key properties of the soil of the area had been conducted (Obalum *et al.* 2011c). Just before setting up the field for this study, six replicate samples of the topsoil (0–20 cm) were randomly collected from the site. Analysis of these samples reveal that the topsoil has mean sand, silt and clay contents of 750, 70 and 180 g/kg soil, respectively thus belonging to the textural class of sandy loam. The soil was acidic with mean pH of 4.8 while having mean organic carbon concentration of 17.88 g/kg soil. The mean value of total nitrogen in the soil was 0.56 g/kg while the mean cation exchange capacity of the soil was 12.40 cmol/kg. Furthermore, the contents of the exchangeable bases were for K⁺, Ca²⁺, Mg²⁺ and Na⁺ 0.04, 3.20, 0.80 and 0.03 cmol/kg soil, respectively.

The experimental field (35 m × 20 m; ~0.07 ha) was cleared, ploughed and harrowed with tractor, after which the soil was further manually harrowed to provide good tilth.

Three factors were considered including seedbed configuration, surface mulching and plant spacing. The experiment had 12 treatments derived from the factorial combination of two forms of seedbed configuration (flat seedbed and raised seedbed) with two status of surface mulching (no-mulch and mulched) and three levels of plant spacing (100 cm × 100 cm, 50 cm × 50 cm and 25 cm × 25 cm, designated wide, intermediate and close spacing, respectively; Table 1). Treatments were replicated four times in a randomized complete block design (RCBD) and were nested in a 2 × 2 × 3 split-split plot design; with seedbed configuration as main plots, surface mulching as sub-plots and plant spacing as sub-sub-plots. Blocks were spaced ~0.75 m apart. The treatment plots (sub-sub-plots) each measuring 3.00 m × 3.00 m were demarcated from one another using earthen bunds 0.30 m high and 0.30 m wide.

Poultry droppings was applied uniformly to all sub-sub-plots at the rate of 10 t/ha, adopted after Ndor and Dauda (2013) and Nwite *et al.* (2013) in studies of fluted pumpkin responses to soil amendments on taxonomically similar soils in the Nigerian savanna. Three weeks later, the sub-sub-plots were pulverized to make flat seedbeds from among which raised seedbeds (level-top beds ~0.25 m high) were prepared according to the field layout of the experiment. Mulch (comprising dry leaves of a grass species mixture) was applied at 10 t/ha on the plots meant for surface mulching; this was done on 9th Jan., 2015. Three days after mulching, fluted pumpkin seeds were sown with the various plant spacings at one seed per hill. The plant spacing of this study gave plant density of 9, 36 and 121 plants per sub-sub-plot in the wide, intermediate and close spacing, respectively, corresponding to 10,000, 40,000 and 160,000 plants/ha, respectively.

The plots were manually watered daily from the time of mulching through maturity until about 11 weeks after sowing (WAS) when rains set in. The watering was done to pre-determined field capacity of the soil, assumed to be its moisture content at –33 kPa (Obalum *et al.* 2011d), down to 60-cm depth. Weeding was done at two-week intervals during the

Table 1. Summary of the various combinations of the factors and ensuing treatments of the study.

Seedbed configuration × Surface mulching		Plant spacing		
		Wide	Intermediate	Close
Flat	No-mulch	Flat/no-mulch/wide	Flat/no-mulch/intermediate	Flat/no-mulch/close
	Mulched	Flat/mulched/wide	Flat/mulched/intermediate	Flat/mulched/close
Raised	No-mulch	Raised/no-mulch/wide	Raised/no-mulch/intermediate	Raised/no-mulch/close
	Mulched	Raised/mulched/wide	Raised/mulched/intermediate	Raised/mulched/close

Wide – 100 cm × 100 cm; Intermediate – 50 cm × 50 cm; Close – 25 cm × 25 cm.

Table 2. Interaction of seedbed configuration, surface mulching and plant spacing on seedling emergence of fluted pumpkin.

Seedbed form	Mulch status	Plant spacing	Seedling emergence (%)	Number of emerged seedlings per plot
Flat	No-mulch	Wide	66.7	6.0
Flat	No-mulch	Intermediate	51.4	18.5
Flat	No-mulch	Close	27.7	30.5
Flat	Mulched	Wide	86.1	7.8
Flat	Mulched	Intermediate	63.9	23.0
Flat	Mulched	Close	49.3	54.2
Raised	No-mulch	Wide	58.3	5.2
Raised	No-mulch	Intermediate	70.8	25.5
Raised	No-mulch	Close	43.4	47.7
Raised	Mulched	Wide	72.2	6.5
Raised	Mulched	Intermediate	72.2	26.0
Raised	Mulched	Close	63.4	69.7
LSD _(0.05)			25.5	

Wide – 100 cm × 100 cm; Intermediate – 50 cm × 50 cm; Close – 25 cm × 25 cm.

study. Agronomic parameters assessed were seedling emergence and fresh leaf yield at two-week intervals. For each sub-sub-plot having different plant densities as per treatment and hence different number of expected plants (NEP) per plot, number of emerged seedlings (NES) was monitored and percentage seedling emergence (%SE) calculated as:

$$\frac{\text{NES}}{\text{NEP}} \times 100$$

To assess fresh leaf yield, harvestable fresh leaves were cut off and weighed. This was done biweekly as from 6 WAS; this first harvest corresponded to 23rd Feb., 2015. Harvest was stopped at 14 WAS when leaf yield of fluted pumpkin normally peaks (Nwite *et al.* 2013). Since dry season and manual irrigation lasted until 11 WAS, the pumpkin was sustained by irrigation in the bulk (roughly four-fifth) of its growth phase and by rainfall in the rest.

Data analysis

Statistical analyses of data was performed by analysis of variance (ANOVA) procedure for a split-split-plot experiment in an RCBD using the software GENSTAT 3, 7.2 Edition (VSN International Ltd., Hemel Hempstead, UK). Significant treatment means were separated and compared using Least Significant Difference (LSD), and all inferences were made at 5% level of probability.

Results

Seedling emergence

The factors under investigation (seedbed configuration, surface mulching and plant spacing) showed interactions in seedling emergence with the highest and lowest

percentage emergence due to treatments flat/mulched/wide and flat/no-mulch/close, respectively (Table 2). These results show that, under limited soil moisture in the dry season, achieving maximum germination and crop stand for fluted pumpkin depends not on seedbed configuration but on pre-sowing soil mulch status and plant spacing.

Hence, the interaction of surface mulching and plant spacing is also presented (Table 3), showing highest and lowest percentage emergence under mulched/wide and no-mulch/close plots, respectively. Notably, seedling emergence tended to decrease with closeness of planting spacing, and surface mulch appeared to compensate for this effect. This role of mulch could be said to be pronounced with closeness of plant spacing, as evident in the fact that no-mulch and mulched plots showed similar values for seedling emergence under both wide and intermediate spacing but not under close spacing (Table 3). The weak role of seedbed configuration vis-à-vis the importance of pre-sowing mulch status and plant spacing in seedling emergence is evident in their main effects shown in Figure 1.

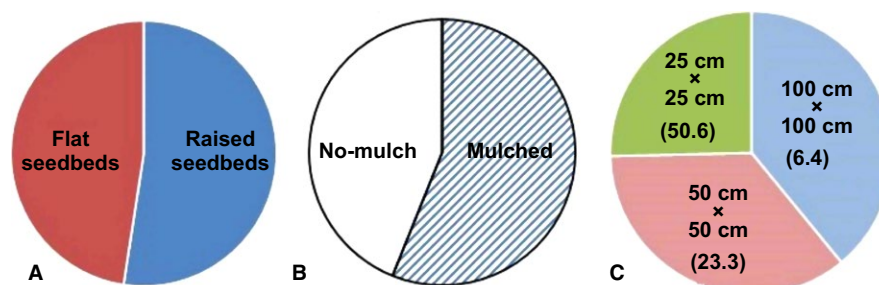
Fresh leaf yield of fluted pumpkin

Seedbed configuration, surface mulching and plant spacing produced significant interaction on fresh leaf yield of fluted pumpkin, with consistently highest values under treatment flat/mulched/close; the only exception was at 6 WAS when the highest values were recorded under raised/mulched/close (Table 4). The data also show that the lowest yields were obtained under treatments flat/no-mulch/wide and raised/no-mulch/wide, except at 10 WAS. Yield increases due to treatment flat/mulched/close relative to flat/no-mulch/wide averaged over 250% (i.e., three and a half-fold increase); that due to raised/mulched/close relative to raised/no-mulch/wide was about 242%. Again, these results

Table 3. Interaction of surface mulching and plant spacing on seedling emergence of fluted pumpkin.

Mulch status	Plant spacing	Seedling emergence (%)	Number of emerged seedlings per plot
No-Mulch	Wide	62.5	5.6
No-Mulch	Intermediate	61.1	22.0
No-Mulch	Close	35.6	39.1
Mulched	Wide	79.2	7.1
Mulched	Intermediate	68.1	24.5
Mulched	Close	56.4	62.0
LSD _(0.05)		17.2	

Wide – 100 cm × 100 cm; Intermediate – 50 cm × 50 cm; Close – 25 cm × 25 cm.

**Figure 1.** Main effects of (A) seedbed configuration, (B) surface mulching and (C) plant spacing on seedling emergence of fluted pumpkin (numbers in parenthesis represent emerged seedlings). Different annotated colors define distribution.

show that the fresh leaf yield of fluted pumpkin under the dry season and droughty soil condition of this study depended less on seedbed configuration and more on soil mulch status and plant spacing.

The interaction of surface mulching and plant spacing is thus shown (Fig. 2). Mulched/close plots consistently produced higher fresh leaf yields compared to the rest while no-mulch/wide plots generally gave the lowest leaf yields. No-mulch/close plots showed rather comparable values with mulched/wide plots. The yields from these two plots averaged 2735 kg/ha while the overall mean yield was 2868 kg/ha. The mulched/intermediate plots out-yielded no-mulch/close plots on some of the harvest dates (Fig. 2). Also the mulched/wide plots out-yielded the no-mulch/intermediate plots on most of the harvest dates. These observations further underscore the role of surface mulch in the interaction presented.

To validate the inferences made on the relative contributions of the three factors investigated, their main effects on fresh leaf yield of fluted pumpkin are shown (Figs. 3–5). Seedbed configuration affected yield with higher values from raised and flatbed seedbeds at 6 and 8 WAS, respectively, beyond which both forms of seedbed produced similar yields with a trend of the former tending to out-yield the latter (Fig. 3). Yield was always higher in mulched plots compared to their no-mulch counterparts, with this mulch effect being more pronounced during 6–10 WAS and being insignificant only at 12 WAS (Fig. 4). On the

average, fresh leaf yield increased in the mulched plots relative to the no-mulch plots by about 74%. The main effect of plant spacing shows that, on most of the assessment dates, leaf yield was higher due to close spacing compared with intermediate and wide spacings for which values were similar on most of the dates (Fig. 5). On the average, leaf yield due to close spacing represented increases over intermediate and wide spacings by about 41% and 86%, respectively.

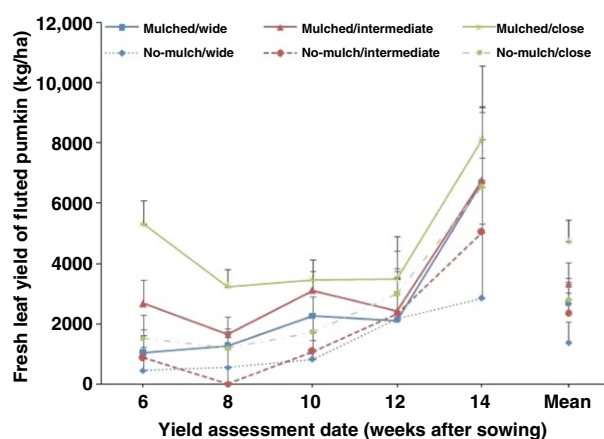
Discussion

Although raised seedbeds provide both better drainage and greater rooting space compared to flat ones, the major aim of factoring in seedbed configuration in this dry season trial was to enhance not drainage but rooting space, the effect on pumpkin root growth of which was evaluated with leaf yield as proxy. Thus, the weak role of seedbed configuration in seedling emergence was reasonably due to the prevailing dry season condition of the study whereby there was no need to drain the seedbeds of excess water. The higher seedling emergence in mulched plots than no-mulch plots could be attributed to the effect of surface mulch in moderating and in making uniform the soil hydrothermal regime (El-Shaikh and Fouda 2008; Hochmuth *et al.* 2015), deemed crucial for seed germination. Wide spacing promoted seedling emergence probably because of the lesser competition to access environmental

Table 4. Interaction of seedbed configuration, surface mulching and plant spacing on fresh leaf yield (kg/ha) of fluted pumpkin.

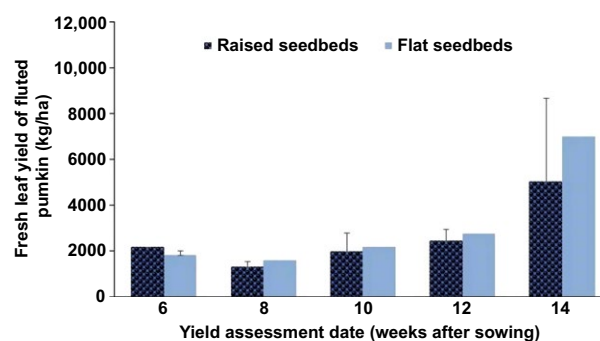
Seedbed form	Mulch status	Plant spacing	6	8	10	12	14	Mean
			Weeks after sowing					
Flat	No-mulch	Wide	396	463	741	2778	3037	1483.0
Flat	No-mulch	Intermediate	519	500	870	2000	6074	1992.6
Flat	No-mulch	Close	1185	1148	1815	3444	7889	3096.2
Flat	Mulched	Wide	1000	1556	2667	2037	6741	2800.2
Flat	Mulched	Intermediate	2741	1630	3315	2222	8667	3715.0
Flat	Mulched	Close	4926	4148	3630	3907	9444	5211.0
Raised	No-mulch	Wide	500	630	889	1519	2667	1241.0
Raised	No-mulch	Intermediate	1204	981	1278	2667	4000	2026.0
Raised	No-mulch	Close	1833	1222	1630	2556	5222	2492.6
Raised	Mulched	Wide	1093	981	1833	2185	6667	2551.8
Raised	Mulched	Intermediate	2593	1667	290	2630	4852	2406.4
Raised	Mulched	Close	5704	2333	3304	3093	6778	4242.4
LSD _(0.05)			1088	887	1057	1989	3496	1037

Wide – 100 cm × 100 cm; Intermediate – 50 cm × 50 cm; Close – 25 cm × 25 cm.

**Figure 2.** Interaction of surface mulching and plant spacing on fresh leaf yield of fluted pumpkin. Error bars represent least significant difference at $P \leq 5\%$.

resources needed for germination. Elhag and Osman (2013) similarly reported that wider spacing had positive effect on germination and percentage emergence of onion (*Allium cepa* L.) at northern Sudan. However, Moniruzzaman et al. (2007), Firoz et al. (2009) and Asaduzzaman et al. (2012) reported that plant spacing had no effect on germination percentage of some vegetable crops in Bangladesh.

The fresh leaf yield of fluted pumpkin was generally insensitive to seedbed configuration. It could be that fluted pumpkin, being a shallow-rooting crop, does not need enhanced rooting space offered by raised seedbeds for increased productivity. Contrary to these results, Ugale et al. (1995) and Deshmuh et al. (2013) reported that ridges and furrows produced higher yields of deeper-rooting pearl millet (*Pennisetum glaucum* L.) compared to flatbeds under rainfed and irrigation systems, respectively in India. Hence, the fact that the present study

**Figure 3.** Main effect of seedbed configuration on fresh leaf yield of fluted pumpkin. Error bars represent least significant difference at $P \leq 5\%$.

thrived on manual irrigation in the dry season was only to partially blame.

The effect of seedbed configuration on fresh leaf yield of fluted pumpkin was inconsistent early in the assessment period, being higher on raised seedbeds than flat seedbeds at 6 WAS and vice versa at 8 WAS. The initially higher yield observed for raised seedbeds might be due to greater availability of soil moisture when the structure of the tilled, pulverized soil was yet to fully reform. Conversely, the subsequent higher yield on flat seedbeds and tendency for such during 10–14 WAS suggests that, after the soil structure reformation, these flat seedbeds sustained more favorable soil moisture than the raised seedbeds that likely had part of the irrigation water percolating down below the reach of the plants. Because of its coarse texture, the soil can be excessively macroporous (Obalum and Obi 2014).

The positive effect of mulch on fluted pumpkin yield was pronounced early in the assessment period, but this effect was insignificant at 12 WAS. These results are

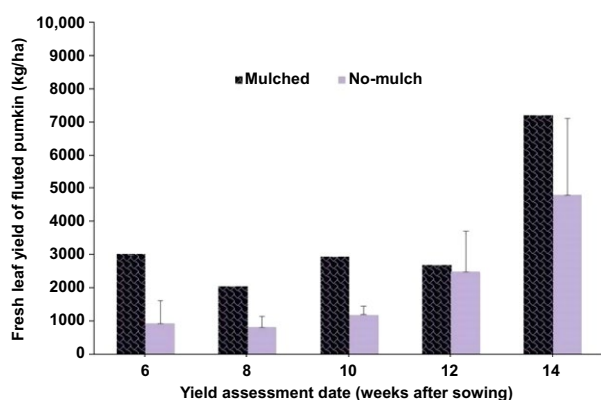


Figure 4. Main effect of surface mulching on fresh leaf yield of fluted pumpkin. Error bars represent least significant difference at $P \leq 5\%$.

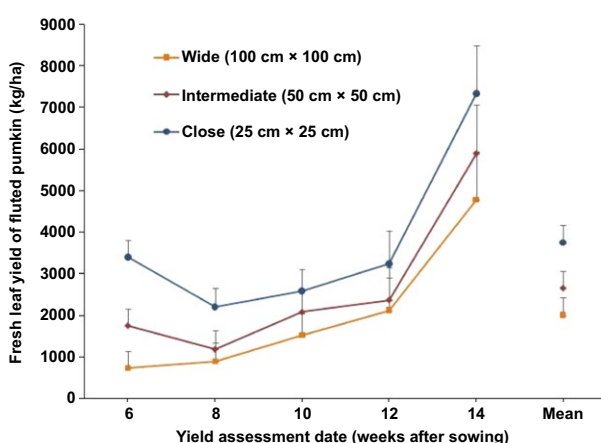


Figure 5. Main effect of plant spacing on fresh leaf yield of fluted pumpkin. Error bars represent least significant difference at $P \leq 5\%$.

explained by the degree of soil coverage due to the crop before and after attaining maturity. The onset of rains about a week earlier might have also contributed to the diminished role of mulch at 12 WAS, to a lesser extent though, by the reason of the higher yield due to mulch later at 14 WAS. This effect of mulching likely resulted from temperature modification, evaporation reduction and hence more uniform soil moisture regime in the mulched compared to the no-mulch plots (Mbagwu 1991; Qin et al. 2015). Our findings agree with the results of Okugie and Ossom (1988) that mulch increased the yield of fluted pumpkin in southern Nigeria. Hudu et al. (2008) and Nwokwu and Aniekwe (2014) reported similar results for other vegetables including watermelon (*Citrullus lanatus*) and tomato (*Lycopersicon esculentum* Mill.) under irrigated conditions in Nigeria. Increases in fresh and dry yields of vegetable crops have been attributed to mulch-induced high soil moisture and the associated optimal transpiration, nutrient uptake and

increased photosynthesis required for plant growth (Mahadeen 2014; Aniekwe 2015).

The progressive increase in yield of fluted pumpkin with reduction in plant spacing are explained by the increase in number of plants per plot with reduction in plant spacing, represented by number of emerged seedlings highlighted in Figure 1. Similar results have been reported for other leafy and fruit vegetables (Firoz et al. 2009; Uko et al. 2013). Contrary reports of higher crop yields at low plant density than at high plant density are usually for tuber crops (Arsenault and Malone 1999; Mauromicale et al. 2003).

In the mulching- $\times$ -spacing interaction, seedling emergence was highest and lowest under mulched/wide and no-mulch/close, respectively, yet these two plots gave similar yields. This similarity was despite the gap in their plant densities – number of plants per plot (see Table 3), thus highlighting the rather equal strengths of mulching and spacing in the interaction. With regard to conserving soil moisture, close spacing plausibly compensated for the absence of mulch by providing coverage just as surface mulch did for wide spacing.

In a fertility trial in a similar environment in south-eastern Nigeria, Nwite et al. (2013) showed that the mean fresh leaf yield of fluted pumpkin from plots amended with poultry droppings at 10 t/ha and grown without mulch at wide spacing was 3575 kg/ha between 6 and 14 WAS. Considering the dry season condition of the present study, the duo of mulched/wide and no-mulch/close with a mean yield of 2735 kg/ha can not only be said to represent the overall mean yield (2868 kg/ha) but to also represent average yields under conventional practice of no-mulch and wide spacing in the rainy, growing season. The observation that highest yield came from mulched/close plots is attributed to the droughtiness of the coarse-textured soil of this study, exacerbated by the prevailing dry season. Even under high plant density, therefore, mulch can enhance fluted pumpkin yield under conditions of limited soil moisture and rainfall.

The insensitivity of fresh leaf yield to seedbed configuration notwithstanding, the effect of surface mulching on leaf yield was more pronounced on flat seedbeds compared to raised ones (see Appendix 1). Also, of the three plant spacings, narrow spacing showed the greatest tendency for higher yield from flat seedbeds than raised ones (see Appendix 2). It is therefore unsurprising that the interaction of the three factors investigated showed that mulched/close combination did better on flat seedbeds than on raised seedbeds.

Conclusion

The data presented support the production of fluted pumpkin in droughty tropical soils with irrigation in the dry season using the combined soil and agronomic

management practice of growing on tilled flat seedbeds with surface mulch (dry grass at 10 t/ha) and at a close spacing of 25 cm × 25 cm. When grown for up to 14 weeks, an average of three and a half-fold increase in mean fresh leaf yield could be achieved with this best practice relative to the conventional practice of growing on flat seedbeds without mulch and at a wide spacing of 100 cm × 100 cm. A close substitute would be to grow the crop on raised seedbeds still with surface mulch and close spacing, if raising the seedbeds rather than leaving them flat subsists the farmer beyond the dry season. In either case of cultivating on flat or raised seedbeds, surface mulching can potentially compensate for wide spacing just as growing without mulch can be compensated for by close spacing. Under conditions of limited mulch material or pumpkin seeds, therefore, irrigated plots without mulch but at close spacing and those with mulch but at wide spacing could have similar agronomic value in terms of fresh leaf yield of fluted pumpkin; a value somewhat in-between the best and the conventional practices.

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Conflict of Interest

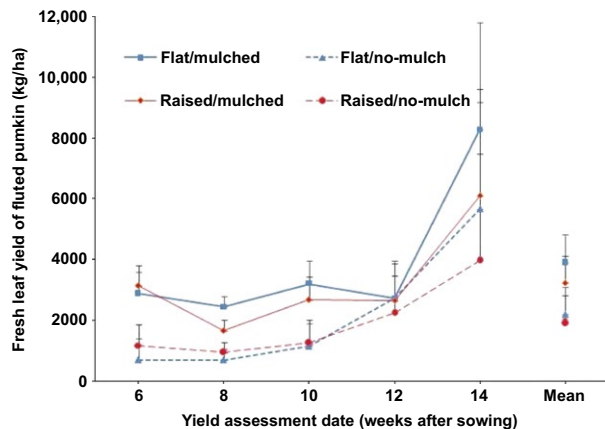
None declared.

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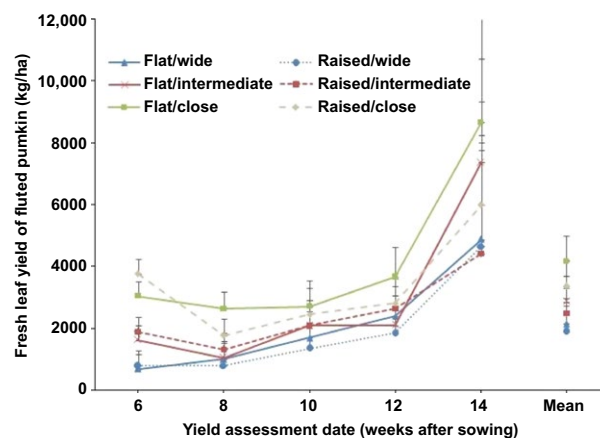
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Appendix



Appendix 1. Interaction of seedbed configuration and surface mulching on fresh leaf yield of fluted pumpkin. Error bars represent least significant difference at $P \leq 5\%$.



Appendix 2. Interaction of seedbed configuration and plant spacing on fresh leaf yield of fluted pumpkin. Error bars represent least significant difference at $P \leq 5\%$.