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Potential of intercropping napier grass with maize during the establishment phase of napier grass

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Abstract

Napier grass (*Pennisetum purpureum*) serves a variety of functions, which include provision of fodder. However, small scale farmers in East Africa need both food and fodder crops. Hence, research to determine the potential of intercropping napier with maize *(Zea mays)* is relevant. This was done using a range of spatial arrangements. In a relatively drought season (1999b), when measurements were limited to the rows closest to napier-in order to determine its competition on maize, double napier rows alternating with single maize rows resulted in 55-68% reduction in maize dry matter (DM) production. The reduction in DM production was only 14% for the additive mixture. The reduction in napier biomass yield for the row closest to maize row(s) was significantly greater, 67-73%, in mixures in which 2 maize rows alternated with single napier grass rows. In a better growing season (2000a), maize DM production during the grain filling period was 19-76% lower in mixtures (depending on spatial row arrangement) compared to the pure stands, and the additive mixture did not exhibit reduction in maize DM production until the dough stage . Maize grain yield and yield components in the additive mixture and the 1:3 napier:maize row arrangement were not significantly lower than the sole maize, and maize was the dominant species in the mixtures. It was concluded that during the first phase of napier growth (before regular cutting back for fodder commences) it is possible to superimpose a maize row between the pure stand napier without much reduction in maize yield (only 5%). The reduction in maize yield in the 1:3 napier:maize rows arrangement was also negligible (6%). However, zero-grazing farmers who are more interested in napier biomass and a bonus of maize yield would take the 3:1 row arrangement. The higher maize yield for the additive mixture and the 1:3 mixture compared to the others, during the first phase of napier growth, was attributed to the higher population of maize plants in these mixtures. However, maize in these mixtures was competitive against the young napier plants and reduced its biomass production.

Key words: Additive mixture, dry matter, fodder, *Pennisetum purpureum*, spatial arrangement, yield

Introduction

Napier grass (*Pennisetum purpureum* Schum.) originated in East Africa (Maher, 1936) and is the predominant forage grass used in zero-grazing livestock production systems throughout East Africa (Abate *et al.*, 1993; Anindo and Porter, 1994). It is also widely used for this and other purposes in other parts of the tropics and subtropics. The grass is important not only as a livestock forage but also for staking various crops (Gollifer, 1973; Niringiye, 2000), provision of mulch, soil erosion control and improvement of soil fertility in general (Bekunda and Woomer, 1996; Niang *et al.*, 1998). It is also important in the construction of mud and wattle houses in rural areas. Therefore, napier grass is extremely important in both socio-ecomic terms and in the support of food security.

Most of the functions the napier grass fullfils require large amounts of biomass and the grass is capable of producing enomous amounts of biomass (Whiteman, 1980; Williams, 1980). In East Africa, it can yield about 25 t ha^{-1} without fertiliser application (Goldson, 1977. Perhaps, maximum napier biomass could be produced when grown in pure stands. Unfortunately, small scale farmers who practice zero-grazing in livestock production in East Africa need both fodder (napier grass) and food crops (Ssekabembe and Sabiiti, 1997). This makes it difficult to promote production of napier grass in pure stands. Therefore, there is need to determine the feasibility of joint production of fodder and food crops on the same parcel of land (Ssekabembe and Sabiiti, 1997).

Research conducted in Kenya showed that it is beneficial to intercrop napier grass with legumes such as *Desmodium uncinatum* and *D. intortum* (Wolfang Bayer, 1990) while experience in India indicated that napier grass is aslo compatible with *Leucaena* (Gill and Patil, 1985). In Uganda, beans are the most important grain legumes and for this reason this crop was tested for compatibility with napier grass- the most important fodder species for zero grazing (Ssekabembe and Sabiiti, 1997). The results indicated that bean yields can be reduced by 32% in the first season of napier growth but when napier becomes firmly established, it becomes very competitive and reduces bean yield by 80%. It was hypothesised that a fast-growing and more competitive crop than beans could be more compatible with napier grass than beans. Maize and sorghum that can grow as tall or taller than resprouting napier were suggested to be the food crops that could fit this scenario. These crops are also fairly competitive for below-ground resources because they are heavy feeders (Purseglove, 1972). Therefore, another experiment was initiated at Makerere University Agricultural Research Institute, Kabanyolo (MUARIK) with the main objective of determining the compatibility of napier grass and maize. An additional specific objective was to determine the best spatial (row)arrangement for this mixture. Since the second phase of napier growth (after it has established a strong root systems and regular cutting back has started) presents markedly different competitive effects, only the results of the first phase of napier grass growth (before regular cutting back for fodder commences) intercropped with maize are presented in this paper.

Materials and methods

The experiment was carried out at two locations. The first trial was done in 1999b (i,.e. second rains of 1999), at Makerere University Agricultural Research Institute, Kabanyolo (MUARIK; 0° 28'N, 32° 37'E), 17 km NE of Kampala. The experiment was repeated in 2000a (i.e., first rains of 2000), *albeit* with some modifications of the treatments, at Namavundu village, located 3 km away from MUARIK, which is also the nearest station where meteorological records are taken. The altitude at Kabanyolo is 1200 m and the soils are mostly Oxisols and highly weathered. Both locations had been under grass fallow for several years. The mean daily maximum and minimum temperatures of the area are about 27 and 17°C, respectively. Rainfall distribution is bimodal with April and November as the usual wettest months, but rainfall distribution has been unpredictable in the recent past. The average annual rainfall is 1300 mm.

The napier grass variety used at MUARIK was ILCA16791, which has been reported to be better than the other locally available varieties (Ssekabembe, 1998). However, at Namavundu another variety that was not previously tested (Cameroun) was used because the available planting material from ILCA16791 was severely infested with a suspected virus disease. This problem increased during the off season and lowered the population of healthy plants. This made it difficult to have a second phase of napier growth (after regular cutting commences) at the same site. This is the major reason why the experiment was replanted at Namavundu, hence providing a replicate of the first phase of napier growth.

In both cases, the "replacement series" treatments were spatial row arrangements ranging from 100% napier to 100% maize. According to de Wits "replacement series" technique of forming mixtures (Willey and Osiru, 1972) one row of napier was taken to be equivalent to one maize row. In both trials, the 50:50% mixture consisted of single alternating rows as well as double alternating rows (zonal arrangement). Both trials carried an "additive" mixture in which the recommended pure stand plant population of one species is superimposed on that of the other species, which increases the total plant population per unit area. In effect, between each two rows of pure stand napier, a maize row was planted to form the additive mixture. At Namavundu, the 2:1 napier: maize mixture, in which maize

DM yield reduction was highest at MUARIK, was dropped in favour of a mixture with a higher proportion of maize (1:3 napier: maize). For some "replacement series" treatments in the first trial, below-ground black polythene sheets were placed in trenches dug 40 cm away from the row to prevent the roots of either species from interacting with the other. The sheets were placed up to a depth of 50 cm into the trenches, and the soil returned beginning with the subsoil. The idea was to estimate the effect of below-ground interaction between the species. Due to the difficult of installing below-ground partitions and since below-ground partitions did not show significant below-ground interaction between the two species, at MUARIK, the treatments with below-ground partitions (+P) were also dropped at Namavundu. Hence, the range of treatments were fewer in the replicate of the experiment, and these are shown in Table 1.

Therefore, there were 11 treatments at MUARIK (1999b) and these were reduced to 7 at Namavundu (2000a). In each case, the treatments were arranged in a randomized complete block design with three replications. The plots in each block were 5.5 m long and 5 m wide with 50 cm borders between plots. Napier was grown on 80 cm rows with 50 cm between plants on the row. Maize (variety Longe 1) was also grown on 80 cm rows but spaced 30 cm within the rows. The plots were weeded 3 times in each season. In each season, napier was cut for the first time 4 weeks after maize harvest. Maize matures before the end of each growing season but the first cut for napier (harvesting) is delayed in order to allow the stems time to harden adequately and store organic nutrient reserves in the root stalks that allow resprouting after cutting (Blaser *et al.*, 1955; Sollenberger *et al.*, 1988). Thus, maize grain yield was determined as soon as it matured and was harvested and dried while napier biomass was determined at the end of the growing season (before the onset of the dry season).

Napier biomass yield was determined after oven drying the samples at 60°C for 48 hours. The number of maize and napier rows in the harvest samples depended on the proportion of each species in the treatments but the total sample area was kept constant for all treatments. At MUARIK, where below-ground partitions had been installed, an opportunity was taken to assess the compatibility of the two species, by assessing the competition between two species. Competition is mostly reflected at the interface of the intercrops (the rows closest to the other species in the mixture). Therefore, maize DM was based on the rows closest to napier grass in order to gauge its competition on maize. Total maize DM production was determined along a 2 m length for the rows closest to napier-the rows further away are more or less not influenced by napier grass. More measurements were done at Namavundu. For maize, these included DM production during the grain filling period, grain yield and yield

Table 1. Spatial arrangements used in the napier grass + maize intercropping system at Namavundu, Uganda, 1999-2000.

First trial (at MUARIK)*		Second trial (at Namavundu)	
Napier:maize rows	%	Napier:maize rows	%
0:All	0:100	0:All	0:100
2:1 (-P)	67:33	3:1	75:25
2:1 (+P)	67:33	2:2	50:50
1:1 (-P)	50:50	1:1	50:50
1:1 (+P)	50:50	1:1 (Ad)	50:50
2:2 (-P)	50:50	1:3	25:75
2:2 (+P)	50:50	All:0	100:0
1:2 (-P)	33:67		
1:2 (+P)	33:67		
1:1 (Ad,-P)	50:50		

* -P means without below-ground partitions while +P means with below-ground partitions; Ad indicates the additive mixture and partitions were impossible to install in this treatment.

components, stover dry weight, leaf area per plant (using linear measurements) and plant height at 50% anthesis. Maize DM production was based on 1 m length of samples across the entire width of the plots. The dry matter was determined twice-when the majority of plants were at the blister-milk stage of maize growth and at the dough stage (Hanway, 1963). This is also the time when maize is harvested for silage A 3 m-length sample across the width of the plots was used to determine grain yield and yield components. It was not possible to determine maize grain yield and yield components at MUARIK due to a terminal drought that affected the crop during reproductive growth. However, grain yield is often positively related to and could be predicted from total DM yield especially at flowering time (Hay and Walker, 1989; Isse Mohamud Abdi, 1997). Therefore, determining maize DM production during the reproductive growth period at MUARIK was a fair way of estimating its grain yield and hence, assessment of the potential of the napier + maize mixture. Measurements for napier grass included canopy height, number of tillers per plant and biomass yield at the first cut.

Results and discussion

Although planting was done quite early, during the first trial at MUARIK (1999b), there was prolonged drought which coincided with the reproductive growth for maize. When it was certain that maize would not mature normally during the persistent drought, the crop was harvested for total DM production when the plants were almost at the milk stage. The weather did not improve to have any meaningful grain yield data on part of the plots reserved for the purpose. Theoretically, drought between maize tasselling and silking leads to a delay in silk exertion and reduced seed set (Onwueme and Sinha, 1991). Continued drought into the linear growth phase of kernel development is expected to reduce the average seed weight as a result of reduced assimilate production or duration of the grain filling period (Lorens *et al.*, 1987). As indicated earlier, DM production at flowering time provides a good prediction of grain yield.

Compared to the pure stands, maize DM yield for the first row nearest to napier grass was significantly lower ($P<0.01$) in most mixtures with napier grass (Table 2). The reduction in maize DM yield ranged from 14 to 68%, depending on spatial row arrangement. It was particularly higher for mixtures with double rows of napier alternating with a single maize row. For instance, maize DM reduction in the 2:1 mixture with partitions was 68% compared to 14% in the additive mixture. The reduction in maize DM yield for the additive mixture was not significant ($P<0.01$). These results suggest that double napier rows shaded maize more than single napier rows. Even when other

Table 2. Maize total DM production prior to the milk stage and the first napier biomass yield when the species were intercropped with and without below-ground partitions at MUARIK in 1999b.

Spatial row arrangement		Total maize dry matter		Napier dry matter	
Napier:maize	rows	g 2m^{-2} row length	% yield reduction	g m^{-2} row length	% yield reduction
0	All	4.4	55	5.4	45
2	1 (-P)	2.0	55	5.4	45
2	1 (+P)	1.4	68	4.2	57
1	1 (-P)	2.4	45	5.8	41
1	1 (+P)	2.6	41	5.8	41
2	2 (-P)	2.3	48	6.2	37
2	2 (+P)	2.4	45	6.1	38
1	2 (-P)	3.3	25	3.2	67
1	2 (+P)	4.9	+11	2.6	73
1	1 (Ad)	3.8	14	7.1	28
All	0	-	-	9.8	
$LSD_{0.01}$		1.47		2.67	
CV (%)		29.1		27.7	

environmental resources are available to crops, reduced availability of solar radiation to a crop can severely limit its productivity (Ottman and Welch, 1989). Shading (competition for light) can even be expected to lower the ability of the shaded plants to exploit other environmental resources fully (Donald, 1958; 1963) and hence, a reduction in yield. However, in this particular experiment below-ground competition seems not to have been a strong factor, during the establishment phase of napier grass when its root system is not yet fully developed. Except for the 1:2 napier:maize rows mixture, during the said period maize DM yield for similar "replacement series" treatments with- versus without partitions were not significantly different (P<0.01).

As with maize, napier DM production for the row closest to maize was significantly (P<.01) lower in all mixtures except the additive one. The reduction in napier DM was particularly high when double maize rows alternated with single napier rows, being 73% for the 1:2 mixture with partitions and only 28% for the additive mixture. As with maize DM production, the difference in napier DM production in pure stand and in the additive mixture was not significant (P<0.01). The results indicate the dominance of maize in the 1:2 mixture. Maize dominance of the young napier plants was also apparent in mixtures with single maize rows. That napier biomass was higher in the additive mixture than in the 2:1 napier:maize rows mixture may be explained by greater intraspecific competition in the latter mixture. It seems penetration of light to both species was better in the additive mixture than when double rows of either or both species alternated with the other species.

The results of the first trial, at MUARIK, showed that in a relatively dry year (1999b) DM production on the first rows closest to the other species was significantly (P<0.01) reduced in most mixtures but the additive mixture was generally an exception despite the higher total plant population. In the trial that followed at Namavundu (2000a), the weather was better than during the first trial. It was generally conducive to better plant growth. The results on vegetative growth parameters during the latter trial are shown in Tables 3 and 4.

Compared to the pure stand, maize plant height was significantly (P<0.01) lower in the 3:1 napier:maize mixture, indicating that maize was not competing much for light in this mixture. On the other hand, there could have been some competition for light in the additive mixture (especially when compared to the 1:1 "replacement series" mixture) and the 3:1 mixture. This is because the maize plants in this mixture tended to be taller than those in the pure stands. The tendency for intercropped plants to grow taller than the pure stands suggests competition for light, and this was also reported when finger millet was intercropped with a tall sorghum variety (Ssekabembe, 1983). However, in the present study the difference was not significant (P<0.01). Similarly, maize leaf area per plant was generally not influenced by intercropping. Napier tillering was highest in the pure stand than in the mixtures and was significantly reduced especially in the additive mixture (P<0.01). This could be

Table 3. Effect of intercropping napier with maize on some vegetative growth parameters, at Namavundu, Ugnda in 2000a.

Spatial row arrangement		Maize		Napier grass	
Napier:maize		Height (cm)	Leaf area/plant m^2	Tillers per plant	Canopy height (cm)
All	0	-	-	9.1	129
3	1	138	0.496	9.2	117
2	2	174	0.430	7.1	116
1	1	156	0.582	5.5	109
1	1(Ad)	182	0.403	3.3	100
1	3	182	0.476	6.6	124
$LSD_{0.01}$		32	-	2.4	23.7
CV (%)		10.5	33.0	11.2	19.2

explained by reduced availability of light at the base of the plants (although in the first trial it was postulated that the additive mixture could have reasonable light penetration-perhaps this does not occur as far as the base of the stem where tillers originate from. A high light intensity that also penetrates to the tiller buds normally promotes tillering through provision of surplus photoassimilates for tiller growth and through a reduction in auxin content (Ibrahim and Asse, 1976; Mohamed and Marshall, 1979; Olugbemi, 1984). However, data on napier canopy height does not suggest that competition for light was prevalent in the additive mixture (where napier plants were significantly ($P<0.01$) shorter) as well as in the other mixtures since canopy height was greater in the pure stand.

Maize total DM production at the blister and dough stages is shown in Table 4. Maize DM was generally lower in mixtures than in the pure stands but this difference was not significant ($P<0.05$) in the 2:2, 1:3 and the additive mixtures, at the blister stage. The 3:1 and 1:1 napier: maize rows mixtures had the greatest reduction in maize DM at both growth stages but when the species were paired or grown in the 1:3 and additive mixtures, the reduction in DM production was relatively small. The additive mixture had a low reduction in maize DM production at the dough stage and even an improvement in DM production at the earlier stage. This is probably because the additive mixture has a higher maize population than the other mixtures. The maize population in the additive mixture was 34709 plants ha^{-1} compared to 31250, 20834, 20834 and 10417 plants ha^{-1} for the 1:3, 1:1, 2:2 and 3:1 napier: maize rows mixtures, respecitvely. The maize population in pure stand was 41667 plants ha^{-1}.

Maize grain and stover yields in the second trial, at Namavundu, are shown in Table 5. Maize grain yield was highest in pure stands but the reduction in grain yield was significant ($P<0.05$) only in the 2:2 and 3:1 napier:maize mixtures. The lowest reduction in grain yield was exhibited by the 1:3 and the additive mixtures. Stover yield was also greater in pure stand than in mixtures. The reduction in stover yield was significant for all mixtures ($P<0.01$). As with grain yield, the reduction in stover yield was greater in mixtures with 2 or 3 napier rows. The reduction in stover yield was also less in the additive mixture and the 1:3 napier: maize mixtures, and was actually negligible in the case of grain yield from these mixtures. For the additive mixture, maize yield and hence, benefits from the mixture, could be increased (or the reduction in yield minimised) by staggered planting of the two species, i.e., by delaying planting of napier grass by 2-3 weeks to give the maize a head-start in growth. Staggered planting time enables peak periods of growth of the intercrops, and hence, competition, not to coincide (Rajat De and Singh, 1981). The possible reduction in napier grass growth and DM production may be overcome when maize matures and is harvested earlier leaving napier grass to exploit the space and environmental resources previously shared with maize. By planting beans 10 days before maize,

Table 4. Maize total DM production at the blister and dough growth stages for the napier grass + maize mixture at Namavundu, Uganda in 2000a.

Spatial row arrangement Napier: maize		Blister stage		Dough stage	
		kg ha^{-1}	% reduction	kg ha^{-1}	% reduction
All	0	-	-	-	
3	1	1153	76	2600	70
2	2	3547	26	6427	27
1	1	1767	63	2853	68
1	1(Ad)	5807	+21	5847	34
1	3	5453	+14	7147	19
0	All	4800		8800	
$LSD_{0.05}$		3391		5099	
CV (%)		47.7		49.9	

Francis *et al.* (1982) were able to attain a 60-89% increase in bean yield relative to simultaneous planting, when beans with a bush growth habit were used.

The results of the experiment indicate that in the first phase of napier growth, maize is more competitive than the young napier grass plants. Replacement of some maize rows with napier (in the 1:3 napier:maize rows mixture) apparently does not result in a significant drop in maize yield. Similarly, in the additive mixture the presence of napier is almost negligible in the first phase since maize yield for this mixture is comparable to the sole maize. Pairing the rows (2:2 mixture) did not increase maize yield above that of the alternating single rows (1:1) presumably because the napier grass is not yet so competitive and zoning it does not make a significant reduction in terms of competition with maize. The partial LERs for maize also indicate that maize was more competitive than napier in all the mixtures. The maize partial LERs realized in all the mixtures were higher than the expected ones.

The high maize grain, DM (blister and dough stages) and stover dry weight reductions in the mixtures with a higher proportion of napier is attributable to the lower maize population in these mixtures. It is also plausible to suggest that the higher yield of the additive mixture (1: Ad) compared to the 1:1 "replacement series" mixture is due to the higher maize population for the additive mixture. Thus, regression of the maize population in the various mixtures (1 = 3:1 napier:maize; and 6 = pure maize) versus the attained grain yield was positive and highly significant ($P<0.003$). As indicated in Figure 1, 90% of the variation in maize yield is explained by the maize population in the tested treatments. Similar conclusions have been made for the first year of the maize + *Robinia pseudoacacia* mixture (Ssekabembe and Henderlong, 1991). Ebwongu *et al.* (2001) also concluded that yield advantages appear to be achievable at higher plant densities of the potato + maize mixture because only the additive mixture gave a yield advantage on the basis of the Land Equivalent Ratio (LER) method of assessing the productivity of crop mixtures.

Maize grain yield components are shown in Table 6. Both yield per plant and number of grains per cob were lower in sole maize than in mixtures, but the difference was significant only in the 3:1 mixture ($P<0.05$). This is probably because intraspecific competition was generally higher than interspecific competition with the young napier plants. The 100 grains weight was not significantly influenced by intercropping the two species.

Total napier DM production at the first cut is shown in Table 7. Napier DM was greater in pure stand than in the mixtures except the 3:1 napier: maize rows mixture. The 1:3 mixture produced almost the

Table 5. Total maize grain and stover yields in the second trial of the napier + maize mixture at Namavundu, Uganda in 2000a.

Spatial row arrangement Napier : Maize		Grain yields		Partial LER*	Stover yields	
		kg ha^{-1}	% reduction		kg ha^{-1}	% reduction
All	0	-	-	-	-	
3	1	509	60	0.39(0.25)	662	81
2	2	686	46	0.54(0.5)	1251	64
1	1	957	25	0.75(0.5)	1858	47
1	1(Ad)	1220	5	0.95(0.5)	2720	22
1	3	1196	6	0.94(0.75)	2720	22
0	All	1280			3482	
LSD0.01		593			634.0	
CV (%)					16.5	

Values presented in brackets are the expected partial LERs on the basis of the land area occupied by maize in the respective mixtures.

same amount of napier DM as the additive mixture, which has a higher population of napier plants. This indicates that maize was very competitive against the young napier plants in the additive mixture. This competitiveness against napier was also partly reflected in reduced napier tillering and canopy height, which were more marked in the additive than in the other mixtures. Comparison of the partial LER and the expected partial LER (Willey, 1979) also indicates the competitiveness of maize not only in the additive mixture but also in the 1:1 "replacement series" mixture. This competition is somewhat reduced in the 3:1 and 1:3 napier: maize rows mixtures; napier partial LERs were higher than expected in these mixtures.

Conclusion

Overall, the results of the present study indicate that during the first season, a farmer interested more in maize grain than napier biomass, can select the 1:1 additive mixture and the 1:3 napier: maize rows mixture. Both mixtures contain a higher population of maize plants than the others. In these mixtures maize grain yield was not considerably reduced compared to the pure stand. Moreover, in addition to the grain yield, these mixtures offer appreciable amounts of napier biomass for livestock feeding. In the previous napier + beans experiment (Ssekabembe and Sabiiti, 1997), a mixture which consisted of more bean rows (1:4 napier grass:beans rows) was similarly recommended for farmers who need a

Table 6. Maize grain yield components during the first phase of napier growth when maize was intercropped with this forage species at Namavundu, Uganda in 2000a.

Spatial row arrangement Napier:maize rows		Yield per plant (g)	No. of grains per cob	100 grains weight (g)
All	0	-	-	-
3	1	130	417	32
2	2	78	215	37
1	1	83	234	36
1	1(Ad)	73	217	34
1	3	72	196	36
0	All	66	189	35
$LSD_{0.05}$		53	171	5.7
CV (%)		35	38.4	9

Table 7. Total napier grass DM production at the first cut (5 months after planting) at Namavundu, Uganda in 2000a.

Spatial row arrangement Naper:Maize rows		Total dry matter (kg ha^{-1})	Partial LER*
All	0	21698	-
3	1	19142	0.882(0.75)
2	2	10833	0.499(0.5)
1	1	8727	0.402(0.5)
1	1(Ad)	8969	0.413(0.5)
1	3	7095	0.327(0.25)
0	All	-	
$LSD_{0.05}$		6897	

Values presented in brackets are the expected partial LER on the basis of the land area occupied by napier grass in the respective mixtures.

reasonable bean yield with some additional napier biomass for stall-fed cattle or sale. On the basis of the present and the previous experiment, it appears that the optimum spatial arrangement of the napier grass + food crops mixture ranges between 33:67% and 25:75% napier grass + food crops arrangement, i.e., mixtures that contain a single row of napier grass alternating with 3-4 rows of the food crop. One *Calliandra* row alternating with 3-4 rows of napier grass has also been recommended for maximum fodder yields (Franzel *et al.*, 1998).

However, the recommendation is different for zero-grazing farmers who do not wish to jeorpadize the availability of napier grass biomass for the livestock although some maize yield is also appreciated at the same time. In this case, the farmer could adopt the 3:1 napier: maize row arrangement because in this mixture napier grass biomass is not significantly lower than that from sole napier grass yet it offers appreciable additional amounts of maize yield. A notable finding from the present study is that for the first farmer, the additive mixture provides reasonable maize yield in the first phase of napier grass growth when maize is more competitive than napier grass. However, the additive mixture may not sufficiently fulfil the requirements of the second zero-grazing farmer, and the recommendation for the first farmer may not prevail when napier grass cutting commences-after the species develops a fully developed and competitive root system.

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