Creating Niches for Integration of Green Manures and Risk Management through Growing Maize Cultivar Mixtures in Southern Ethiopian Highlands[1]

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Abstract

Maize yield fluctuation in small scale farms of East Africa is associated mainly to intermittent drought, soil fertility decline and choice of intercrops. Field experiments were conducted between 2000 and 2004 in Areka, Southern Ethiopia to evaluate whether maize cultivar mixtures have yield advantage over pure stands under sub-optimal conditions but also to quantify the productivity of vetch (Vicia dasycarpa) as a green manure crop under intercropping with maize mixtures or pure stands. Mid-late maturing, A511 (145 days, 2.45m tall) and early maturing, ACV6 (120 days and 2.04m tall) maize varieties were grown either in pure stands or in mixtures of the two cultivars with or without intercropping, in fertile or less fertile farm plots. Under sole cropping, the grain yield of mixtures was significantly higher (by 1.5 tha^{-1}) ($P<0.05$) than early variety, cv ACV6, but lower than the late maturing variety, cv A511, across years. Similarly, the grain yield of mixtures was significantly higher than sole cv ACV6 but lower than A511 in fertile plots while ACV6 out yielded both late maturing variety and the mixtures in less fertile plots. Intercropping with vetch did not affect the yield of mixtures while it caused a significant yield decline in A511, by about 35% ($p<0.05$), particularly in years with intermittent drought. On the other hand, vetch biomass was significantly reduced under intercropping with maize, by 94% in A511 but 66% in mixtures. Vetch was more sensitive to low soil fertility than maize. Farmers' evaluation indicated that cultivar mixtures could intensify their systems by leaving space for intercropping, shortening hunger period, minimizing risk of complete crop failure and as a stake. However, the adoption of this technology would depend on the availability of compatible varieties with similar grain colour, size and shape that otherwise would affect the market value of the produce.

Keywords: Systems intensification; Intercropping; Cultivar mixtures

Introduction

Farmers in maize-dominated areas of East Africa commonly experience maize crop failure due to variable rainfall distribution. The effect could be complete crop failure if the dry spell coincides with the flowering period (Amede, 1995). Few farmers responded to this variable environment by growing different maize varieties with different flowering periods on different farm plots where as the majority of farmers still prefer to grow late maturing varieties mainly because these varieties produce higher grain yields than the early maturing ones, particularly in years with favourable conditions. In this scenario early varieties may not be preferred, as growing only the early cultivar would lead to a poor yield in good years, since resources would not be fully utilized due to short duration of their photosynthetic period (Rao *et al.,* 1990), small leaf area index and low water and nutrient use efficiency (Kamara *et al*., 2003).

Growing mixtures could make an important contribution in risk-prone and variable environments by minimizing crop failure due to biotic and abiotic stresses and secure harvest and nutritional balance particularly

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in small scale production systems. Cultivar mixtures offer additional diversity in the time of germination, flowering, growth, seed filling and harvest (Anonymous, 1988) which could be translated to yield increase of 5-15%, reduced pesticide inputs and improved stability of yield and quality over single varieties (Newton *et al*., 1998). Research with various crops have shown that intra-specific cultivar mixtures with some genetic variability often yield more than pure stands (Panse *et al*., 1989; Newton *et al*., 1998) and the benefit was apparent in barley due to better disease resistance (Newton *et al*., 1998) and in beans due to enhanced drought resistance (Mkandfawire, 1988). Earlier findings showed that when two maize varieties with synchronized flowering time, early tassel from the late maturing variety with late silks of the early maturing variety, are grown in mixtures under drought probe regions grain yield of mixtures was significantly higher than either component under pure stands (Amede, 1995). The yield advantage of mixtures was the highest in bad seasons. The reasons behind were that firstly there was a spatial and temporal difference in resource utilization among components. Secondly synchronization of the flowering (tasseling of one and silking of the other) improved seed setting. Moreover, one of the components may recover from intermittent drought with occasional showers and benefit in terms of space and time due to less competition for resources from neighbouring plants. Besides, there is an associated benefit in that relay cropping of legumes or root crops was possible once the drought affected variety or the early maturing component is harvested.

Besides drought, soil fertility decline is one of the major constraints of production and food insecurity in the region. Farmers found it expensive to replenish soil fertility due to increased price of inorganic fertilizers. Earlier attempts to integrate green manure legumes in the maize system were not successful due to very high opportunity costs of land and labour to grow legume cover crops at the expense of food crops (Fischler *et al*., 1999; Amede and Kirkby, 2004). On the other hand, farmers in the region practice intercropping systems with food crops though maize yield was reduced by up to 25% when intercropped with beans (Chemeda, 1997). The situation became different when it comes to intercropping non-food legumes for soil fertility management. Intercropping a green manure crop, Crotalaria, with maize reduced maize yield by 40% (Fischler *et al.*, 1999) while it improved the grain yield of the following maize crop significantly. However, farmers in Western Kenya refused to adopt this technology amid positive effect on the following crop (personal observation, 2001). The implication was that farmers were willing to integrate non-food legumes under maize only if the intercrop did not affect maize yield and also if it did not compete for space with food legumes in the fertile corners of the farm (Amede and Kirkby, 2004). On the other hand, there are cases where intercrops did not reduce maize grain yield when grown in combinations. Forage legumes like *Medicago lupulina* did not affect maize yield when intercropped under maize (Alfrod *et al*., 2003).

Evaluation of eight herbaceous legume species in southern Ethiopia also indicated that farmers were willing to grow feed legumes under maize (Amede and Kirkby, 2004) and selected vetch (*Vicia dasycarpa*) as the best fitting legume for its very high feed value, short duration and fast decomposition when incorporated into the soil. However due to small land holdings and limited financial capacity farmers were not willing to intercrop vetch in the fertile homesteads and not at the expense of reduced maize yield in the other plots. In this case strategies should be sought whereby legumes like vetch could be integrated into the system without reducing household food production, principally maize yield. We hypothesize that a significant amount of vetch biomass could be produced under maize cultivar mixtures without affecting maize yield. Mixtures could be used as niches in space and time to integrate vetch into the system, particularly in the far away fields where soil fertility decline is apparent and intercropping is rarely practiced. The legume intercrop under mixtures may benefit from less competition from maize due to cultivar differences in height, root distribution and peak demand time for light, nutrients and water.

The objectives of this study were: (i) to evaluate whether maize cultivar mixtures have yield advantage over pure stands under optimum and/or intercropping systems; and (ii) to evaluate the performance of vetch under mixtures or pure stands and quantify its possible effect on maize yield in pure stands or mixtures.

Materials and Methods

The experiment was conducted in Areka, Wollaita zone, Southern Ethiopian Highlands between 2000 and 2004. Areka is situated on 37^o 39' E and 6^o 51'N. The topography of the area is characterized by undulating slopes divided by V-shaped valleys of seasonal and intermittent strips, surrounded by steep slopes. At between 1880 and 1960 m above sea level, this area has mean annual rainfall of about 1300 mm and an average temperature of 19.5 ^{o}C. Rainfall is bimodal, with a short rainy season (belg) from March to June, and the main rainy season (meher) from July to the end of October. The rainfall and temperature amount and distribution during the experimental years is presented in Table 1.

Table 1. Mean rain fall (mm) and temperature (^{o}C) amount and distribution in the growing seasons of Areka, 2000-2004

	2000		2001		2002		*2004*	
	Rainfall	Temp.	Rainfall	Temp.	Rainfall	Temp.	Rainfall	*Temp.*
Months	mm	^{o}C	mm	^{o}C	mm	^{o}C	mm	*^{o}C*
March	55.3	23.3	148.8	20.1	153.8	19.5	42.6	*21.5*
April	196.4	21.1	132.6	19.0	111.0	19.9	293.1	*19.0*
May	161.1	19.5	143.6	18.5	86.4	19.1	106.7	*18.8*
June	120.2	19.0	186.8	17.2	122.7	18.1	116.3	*18.3*
July	156.7	18.2	239.2	16.7	63.1	18.2	149.6	*16.9*
August	178.8	18.2	347.3	17.4	156.5	17.8	248.9	*17.5*
September	166.2	19.2	127.0	17.3	74.8	18.5	119.5	*18.3*
Total	1034.7		1325.3		768.3		1076.7	
Mean	147.81	19.77	189.33	18.02	109.76	18.73	153.81	*18.6*
SE	*17.76*	*0.68*	*30.2*	*0.45*	*14.01*	*0.3*	*32.97*	*0.55*

In the Wollaita farming systems, soil fertility gradient decreases within a farm with distance from the home due to management differences, with the homestead fields being very fertile while the out fields being less fertile across farms and households (Amede and Taboge, 2004). Thirteen years soils data from the site indicated that typical homestead fields have a pH (H_2O) of 6.1, and contain 4.2%, 0.16%, 13ppm, 0.96 (me/100 g soil), 14.04 (me/100 g soil), and 2.93(me/100 g soil) organic matter, total nitrogen, phosphorus, potassium, calcium and magnesium, respectively, while the outfields have a pH of 5.9 and 1.9%, 0.11%, 7ppm, 1.5 me, 9.06 me and 1.61 me of organic matter, total nitrogen, phosphorus, potassium, calcium and magnesium, respectively (SCRP, 1996). Recent soil analysis also showed similar trends (Amede and Taboge, 2004).

Two improved maize varieties, one mid-late maturing , A511 (145 days of maturity, 2.45m tall) and one early maturing, ACV6 (120 days of maturity and 2.04m tall), which are proven to be compatible to each other (Amede, 1995) were grown as pure stands or in mixtures under on-farm and on station conditions in Areka. Mixtures were formed by mixing equal number of good quality seed from recent selections with similar colour and shape. It was reported earlier that when maize varieties are grown in mixtures under drought-prone environments they produced significantly higher grain yield that either component varieties grown in pure stands (Amede, 1995). In 2000 and 2001 the experiment was conducted on-farm with six and twelve representative farmers, respectively. The 2000 experiment was conducted on-farm in the fertile homestead fields to test whether maize mixtures could yield higher than either sole varieties under relatively high rainfall conditions under pure stands. Since the system is very intensive and intercropping maize with legumes or sweet potato is a common practice the 2000 experiment was modified in 2001, whereby all maize varieties or mixtures were intercropped with vetch onfarm, both in the less fertile outfields and fertile homestead fields.

The on-farm experiments followed a complete block design, considering the simple blocks per farmer as replicates, and each farm consists of six maize varietal treatments, namely cv A511 sole, cv ACV6 sole, mixture of A511 and ACV6 sole, cv A511 intercropped with vetch (*Vicia dasycarpa*), cv ACV6 intercropped with vetch and mixtures of A511 and ACV6 intercropped with vetch. Each of the three varieties were planted on a plot size of 100m^2 and then divided for two plots, sole or intercropped with vetch, with a size of 50m^2. vetch inteplanting was simultaneous with maize in 2001, but it was planted three weeks after the emergence of maize to minimize competitions of vetch with the maize crop. The experiments were conducted by 24 representative farmers from three resource endowment groups (rich, middle and poor) selected by the community to represent the community and form farmers' research group to test and identify technologies addressing the most pressing agricultural constraints of the community (details in Amede et al., 2001). The experiments were repeated in 2002 and 2004 under researcher management conditions. The on-station experiment followed a split plot experimental design with RCBD where by the main plot was maize varieties while the sub-plots were treatments with or without vetch as an intercrop with three replications. The main plot size was 100 m^2 while the sub plots were placed on 50 m^2. The experiment was planted on the 12th of April, 2000 and 25th March, 2001 on-farm following farmers' practices while the on-station experiments were planted on March 22, 2002 and April 22, 2004 following rain fall patterns. Earlier recommendations indicated that these varieties gave the highest yield under 66,000 plantsha^{-1} (Amede, 1995) and hence a spacing of 0.75cm between rows and 20 cm within maize rows was used. Vetch was inter-planted between maize rows 25 days after emergence of maize in all cases. Sole vetch was planted with a spacing of 40 x 10 cm^2 at the recommended seeding rate. Input levels, fertilizer and pesticides, was very low to ensure relevance of the findings to subsistent farmers. In all experiments only 50 kg of Urea and 25 kg of DAP was applied at sowing for the maize fields, while only 25 kg of DAP was applied to the sole vetch fields. All farm operations were done by hand. The experiment was kept weed free under both on-farm and on-station conditions as farmers also weed their maize crop at least twice. Farmers have already grouped themselves into various social categories, namely resource-poor, medium and resource- rich (Amede *et al*., 2001). In 2001 three farmers per group scored (1 to 5) the advantages and/or disadvantage of growing maize mixtures over pure stands one being the least important and five the most important. In addition, possible cash income from selling green cobs of pure stands or mixtures was estimated in 2001. The numbers of purchasable cobs were counted, and the market value of the cobs at the respective harvesting period estimated.

Statistical tests were performed using Jandel Sigma Stat version 2.0 (Jandel Scientific, San Raphael, CA, USA). ANOVA and a minimum P value of 0.05 were used as the significance level for all experiments. All pair wise multiple comparison procedures (Tukey test) was used to detect differences among treatments.

RESULTS

Experimental Conditions

The years 2000, 2001 and 2004 received enough amount of rainfall with good distribution (Table 1) while in 2002 the rainfall amount and distribution was below the area average. However, since the flowering period of the respective varieties of ACV6 and A511 was 54 and 65 days after emergence, respectively, the critical dry spell that appeared in early July, 2002 did not coincide with the critical growth stages. Homesteads were more fertile than outfields regardless of socio-economic strata of farmers, principally because farmers apply most of the organic residues, manure and household refusal around the homestead and near fields. As a result, farm plots close to the homestead gave significantly higher grain yield than outfields with similar amount of experimental inputs (Figure 2). Under on-farm conditions, the maize yield in 2000 was significantly higher than the maize yield of 2001 across varieties ($P<0.05$) (Figure 1), though it was associated with climatic differences butmanagement differences. The maize field in 2001 was intercropped with vetch under both homestead and outfield plots, while it was grown as a sole maize crop in 2000.

Maize Yield of Mixtures

The grain yield of mixtures under sole or intecropping systems across years was higher than the early maturing ACV6 but lower than the late maturing variety A511 except for 2004 (Figures 1&2). In 2004, the grain yield of mixtures was significantly ($P<0.05$) higher than ACV6 under both sole cropping and intercropping with vetch while the mixtures produced at least equal yield with A511 under intercropping systems (Figure 2). Moreover, the grain yield of pure stands or mixtures was affected by soil fertility status whereby the grain yield of maize was significantly lower in non-fertile outfields compared to those grown on fertile homestead plots

(P<0.01) regardless of varieties (Figure 1). In the homestead plots the grain yield of the late maturing A511 was the highest followed by the mixtures and ACV6 while in the outfields the early maturing variety out yielded both A511 and the mixtures. Yield decline due to soil fertility was highly significant (P<0.01), by about 60 and 50% in A511 and the mixtures, respectively (Figure 1b) while the yield decline in early maturing variety, ACV6, was only by 15%.

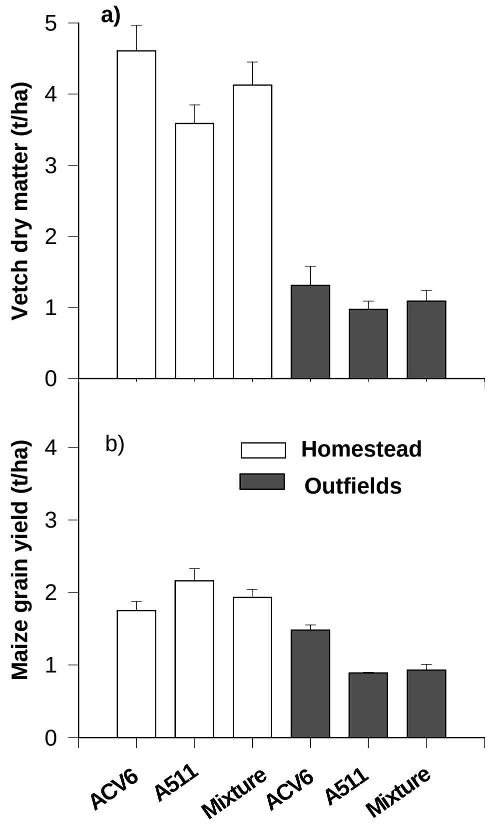

Figure 1. Maize grain yield of mixtures and pure stands under sole crop (a) and intercropping (b) in Areka in 2000 and 2002, respectively. Bars indicate standard errors (SE).

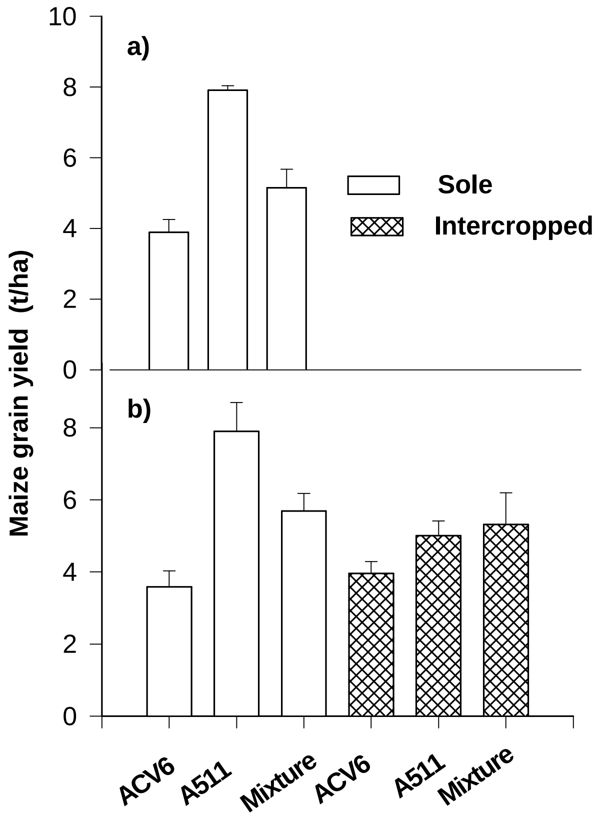

Figure 2. Maize grain yield (b) and vetch biomass (a) of mixtures and pure stands under intercropping systems in fertile (homestead) and less fertile (outfield) on farm plots in Areka, 2001. Bars indicate standard errors (SE).

Under on-station conditions grain yield of maize in 2004 was higher in 2002 (Figure 2) due to reduced rainfall amount and distribution in 2002 (Table 1) . In 2004, both A511 and the mixture produced significantly higher grain yield than ACV6 under sole or intercropping systems ($P < 0.05\%$) while in 2002 the difference between sole and intercropped maize varieties was not apparent (Figure 2a). Vetch intercropping under maize did not affect the grain yield of all varieties in 2002 while it significantly ($P < 0.01\%$) reduced the yield of A511 in 2004, by about 35% (Figure 2b). When grown in mixtures, the plant height of the early maturing variety increased by about 100 mm while the height of the late maturing maize variety remained unchanged (data not presented).

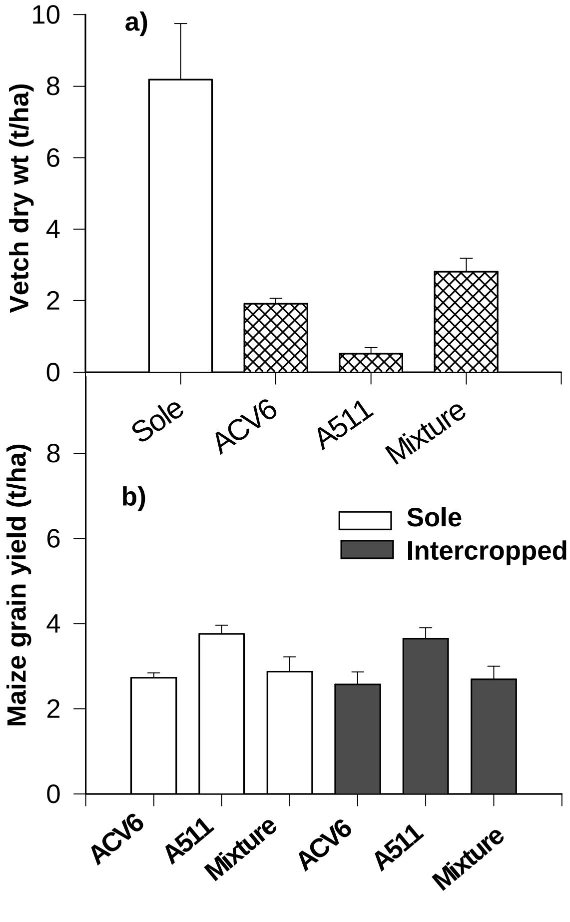

Figure 3. Maize grain yield (b) and vetch biomass (a) of mixtures and purestands under sole and intercropping systems in Areka in 2004. Bars indicate standard errors (SE).

Vetch Yield under Mixtures or Sole

Vetch biomass yield was reduced (P<0.01) by intercropping with maize across years, regardless of varieties. However, Vetch biomass reduction due to intercropping with maize varied with the companion maize varieties (Figure 4). The highest biomass yield was obtained when grown sole followed by intercropping with mixtures and ACV6, with a biomass reduction of up to 94% in A511 and 66% under the mixtures (Figure 4). It was more sensitive to decline in soil fertility than maize when grown in combinations as the vetch biomass was reduced by more than 70% compared to the maize yield reduction of about 30% when grown in the in low fertile outfields (Figure 1b & 3).

Farmers' Evaluation of Mixtures

There was a consensus among farmers of various social category on the major advantages and disadvantages of the technology (Table 2). The highest advantage of growing maize cultivar mixtures perceived by farmers were that the early maturing component of mixtures leaving space for intercropping so that a food or feed legume could be effectively intercropped without affecting maize yield. More over the resource poor and medium category farmers revealed that the mixtures could bring more financial income compared to sole varieties. Its contribution to shorten the hunger period because of early green cob formation was valued by all groups. The biggest disadvantage of mixtures identified by farmers across social categrories was its sesuptibility to wild animals at the early component of the mixtures produce cobs earlier than their local varieties, which was even worth for the sole early maturing variety.

Table 2. Farmers' evaluation on the advantages or disadvantages of maize cultivar mixtures in 2001 at Areka. Each wealth category was composed of at least 5 farmers and ranking was done by consensus. (5 = very high, 1= very low)

Rank	**Resource-Rich Farmers**		**Middle Income Farmers**		**Resource-Poor Farmers**	
	Negatives	Positives	Negatives	Positives	Negatives	Positives
5	Affected by wild animals	Leave space earlier; Shortens hunger period	Affected by wild animals	Leave space earlier; Serves as support for intercrops; Higher income	Affected by wild animals	Leave space earlier; Shortens hunger period; Serves as support for intercrops; Higher income
4	Difficulties in mixture preparation; Labour demand	Support for intercrops	Access to compatible varieties	Minimized risk; Shortening hunger period		Yield advantage
3	Difficulties in harvesting	Minimized risk; Higher income	Difficulties in mixture preparation	Yield advantage		
2	Yield advantage		High labour demand; Problem in harvesting			
1					Difficulties in mixture preparation	Difficulties in harvesting

At that period of time when the early maize was ready as a green cob, late June 2001, the price of maize was 1600 Ethiopian Birr tonne^{-1} , about 200 % in comparison to the harvesting period. Farmers have no cash at this part of the season as their stock is usually eroded in the first three months after the onset of food shortage. When the early maturing maize was at milk stage, no other new crop was brought to market. In situations when farmers sell their produce as green maize they received about 200 USD higher than the neighbouring farmers (Figure 4) who waited for the matured maize. In mixtures, the late maturing component was the main contributor to the combined yield in terms of grain .

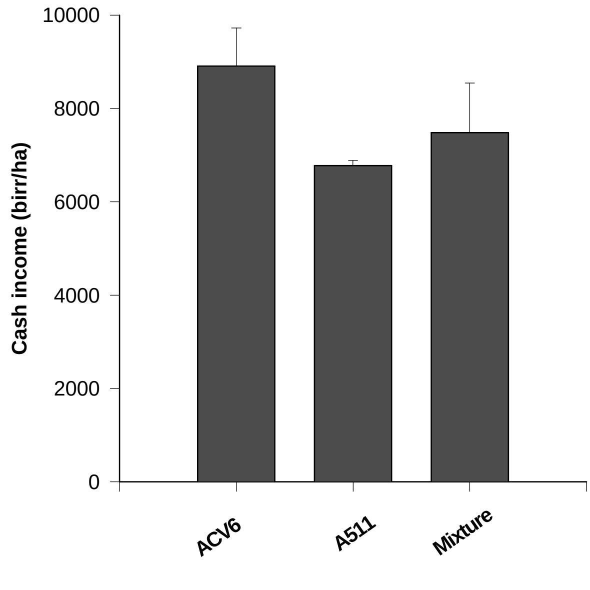

Figure 4. Cash income (Eth birr) from selling maize green cobs of mixtures and pure stands in Areka, 2001 (1 USD = 8.6 Ethiopian Birr). Bars indicate standard errors (SE).

However, the reverse was true in terms of cash income by selling green cobs. With one Ethiopian birr it was possible to buy only 4 green cobs in June but 6 cobs in July. Hence for the same amount of money the early maturing variety had higher value than the late maturing variety. The income level triples with selling green cobs than selling dry grain of maize at any one time of the year.

DISCUSSION

In East African Highlands where land holding is very small (<0.5 ha per family of 6) (Amede et al., 2001), risk crop failure is high, crop yield is low and markets for agricultural produces are unfavourable farmers are practicing multiple cropping systems with relay or intercropping under maize or perennial crops. In this experiment, though the yield of the late maturing maize variety , cv A511, was higher than the mixtures or the early maturing variety , ACV6, growing mixtures is an important intervention towards intensification of the existing systems. Firstly it favoured the growth of intercrops more than the late maturing variety, as it was proven for vetch (Figure 4) with out substantial yield reduction of maize (Figure 2). When ever maize is intercropped with legumes, a maize yield reduction of at least up to 25% with beans (Chemeda, 1997) and 20% with lablab (Mpairwe *et al*., 2002) was recorded compared to sole maize stands. In this work, intercropping with vetch did not decrease maize grain yield of mixtures though vetch was intercropped under maize to coincide with the critical stages of the maize varieties.

Secondly, the early maturing component of the mixtures could be harvested either as green cobs or matured cobs which may leave space and time for a new intercrop to be grown under the remaining late maturing plants of the mixtures as relay crops or otherwise. Once the early maturing variety is harvested, the late maturing variety could be benefited in space and time to grow intercrops, since the maize population/plot would be reduced by half. In this case another relay crop could be considered, particularly where the growing season is long. The benefit could be explained in terms of spatial and temporal distribution of resources, mainly water, nutrients and light that may favour the growth of the intercrops.

Thirdly, it gave farmers the opportunity to distribute the harvest period over months which has an implication on food availability, labour distribution and risk minimization due to abiotic or biotic factors. Growing maize mixtures with variable maturity period could be key intervention to reduce pressure and to maintain versality in the management of labour and the maintenance of a capacity to respond to inter-annual and inter-seasonal fluctuations in the timing and intensity of rains and incidence of pests and diseases (Anonymous, 1988). Whenever there is a delay in silk production of the early maturing component due to drought or any other stress, the pollen from mid-late maturing component pollinated late emerging silks of the early maturing variety and stabilized yield of mixtures and boast productivity (Amede, 1995).

In economic terms farmers obtained significantly high income by growing mixtures (Table 2) due to the high price of green maize at that period of time when all other varieties are still at vegetative stages. The sample data indicated that early maturing varieties gave higher cash income over mixtures and late varieties (Figure 4) but the possibility of selling the whole produce as green cob is low because of limited market opportunities. In this case mixtures would be preferred to distribute risk in marketing produces.

Earlier attempts to minimize the risk of maize crop failure in the drought-prone regions of Ethiopia indicated that maize mixtures-with potentially synchronized late silking of the early variety and early tasseling of the mid late variety- gave 60% grain yield more than the pure stands in dry growing seasons, but only 30% more when there was more rain (Amede, 1995). However, the compensation effect in terms of yield in cultivar mixtures that was found in the semi-arid environments was not achieved under semi-humid conditions. In favourable conditions, competition from neighbouring plants increases as the size and the vigour of the neighbouring plant increases (Mauromicale *et al*., 2003). Similarly maize yield of the mixtures was significantly higher than the early maturing component (ACV6) but lower than the late maturing component (A511) (Figure 1) under Areka conditions. This was mainly because of prolonged rain, which gave the late maturing variety a more competitive condition over the early maturing variety and reduced the contribution of the early component in the mixtures. However, mixtures appear to give an intermediate yield under relatively favourable conditions (Figures 1 and2) probably because of reduced competition for soil water, while the benefits of mixtures was apparent in drought-prone environments with increased risk of crop failure (Amede, 1995).

Risk Management

The results suggested that late maturing variety was more affected by low soil fertility than early maturing varieties and mixtures (Figure 2b). Besides nutrients the negative effect of low soil fertility status on grain yield of late maturing maize could be due to the poor soil water holding capacity of the outfield soils that contain only 30% organic matter compared to soils from homestead fields in the area (Amede and Taboge, 2004). In the fertile plots the late maturing component (A511) was the major contributor to the yield of mixtures while in less fertile plots the contribution of A511 was very low which lead to the low yield of mixtures in comparison to A511 (data not presented). In situations where nutrients and water are limiting, mixtures with considerably large differences in maturity period than the currently tested varieties could perform much better than either components due to differential peak demand for water and nutrients. However the potential benefit from getting pollen from late maturing varieties to fertilize late emerging silks will get lost due to widening anthesis-silking intervals.

Farmers indicated continual supply of pure varieties for creating mixtures as potential constraints. In principle, they may use their own hybrid bulk farm seeds produced through cross fertilization of the early and late maturing varieties and get an additional yield gain. However, use of this seed continuously would preclude continuing with the strategy using mixtures as this would require seed of pure seeds with repeated external supply. In practice, the situation is not different from growing pure varieties as there is a need for continual supply of pure seeds year after year. Since every household uses different maize varieties of their choice the possibility to maintain non contaminated true variety is minimal.

Vetch under Mixtures

Vetch is an early maturing multipurpose legume which could is used as a favourite livestock feed, particularly for milking cows and draught oxen. It is also used as a green manure thanks to its high nitrogen content, easily decomposition characteristics and fast release of nutrients (Amede et al., 2001; Mpairwe et al., 2002). Farmers' evaluation of six legumes species showed that vetch received the highest rank for its improvement of soil water holding capacity, early soil cover, high biomass productivity in a short period of time and high feed value

(Amede and Kirkby, 2004). However, despite proven benefits in improving soil fertility status the adoption of non-food legumes like vetch into the systems of small scale farmers remained very low thanks to the high opportunity costs of land and labour (Amede & Kirkby, 2004). Though intercropping with maize reduced vetch yield significantly ($P< 0.05$) across treatments, vetch yield was less affected by mixtures than by pure varieties as it was observed in 2002 and 2004 (Figure 4). The biomass yield of the companion vetch was proportionally higher in seasons where maize grain yield is low than in years where the companion maize yields was high probably due to reduced competition from maize. In situations where vetch was simultaneously interplanted with maize, like in 2001, the maize crop was dominated by vetch and the vetch produced relatively high biomass, particularly when grown in the homesteads with maize (Figure 3). On the other hand, when the vetch was inteplanted three weeks after the emergence of maize vetch yield was reduce reduced significantly, particularly when grown under the late maturing variety, A511 (Figure 4).

The outfield could be targeted for integrating legumes under the mixtures as farmers did not intercrop any food crop in these degraded outfields. However, though vetch was preferred by farmers as the best legumes for feed and soil fertility restorer (Amede and Kirkby, 2004) it was not growing well under such conditions (Figure 2a), as the biomass yield was reduced by up to 70% when grown in low fertile soils. Vetch was found to be even more sensitive to low soil fertility status than maize (Figure 2) hence the possibility of integrating vetch under mixtures could be done in the middle fields with reasonable soil fertility status. Earlier experiments also indicated that in comparison to other green manures tested on the site the biomass yield of vetch was the lowest under degraded farm lands (Amede *et al.,* 2001). Thus, it calls for identification of legume cover crops that may do well both under fertile and less fertile soil fertility conditions. Moreover, for this type of system to succeed it will require a legume species that is not very competitive with maize so that the maize yield could be maximized for the households (Alfrod *et al*., 2003) and the legume will become an added value as forages and/or soil fertility restorers.

Possible Incentives for Adoption

The results of this study demonstrated that intercropping vetch with cultivar maize could lead to produce a good amount of biomass that could be used for soil fertility management and high feed value as perceived by farmers (Table 2) but also improve the feed quality of the straw (Mpairwe *et al*., 2002). However, the adoption of this technology demands that the different varieties identified for producing mixtures have a similar grain colour, size and shape that otherwise would affect the market value of the produce. The late maturing stand could also serve as a support for the intercrops like beans after removing the stalks of the early maturing variety to create space for other intercrops. The availability of compatible varieties and planting material for the next season were also mentioned as potential factors for non-adoption. In general, with the current trend whereby the rainfall amount and distribution is becoming unreliable the move towards cultivar mixtures would enable farmers to minimize the risk of complete failure and create an opportunity for further intensification through better intercropping systems.

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