Original Research Article

EFFECT OF INTERCROPPING *SONCHUS OLERACEOUS* WITH MAIZE AND COWPEA ON BIOMASS AND SOIL CONSERVATION

ABSTRACT

Maize and cowpeas are important staple foods in Kilifi county and their productivity is highly constrained by increased incidences of pests, weeds and prolonged drought. These adversely affect maize yields and availability of cowpea leafy vegetables during the dry seasons. *Sonchus oleraceaous*, a common weed in most maize-cowpea cropping systems is widely used and most preferred in most households of the Kenyan coast as a delicacy and a leafy vegetable. It is readily available throughout the year due to its drought tolerance characteristic unlike cowpeas. However, its role as a vegetable and cover crop have not been exploited and or documented. This creates the dilemma as to whether it is a weed or is an important plant which farmers should incorporated in food farming systems. This study was conceived to investigate the effects of *Sonchus* on maize-cowpea cropping systems, specifically as a cover crop. A randomized complete block design experiment replicated thrice was set at Pwani University Crop Science farm for two (2) cropping seasons in 2014 to 2016. Treatments included three (3) intercropping systems composed of maize, *Sonchus* and cowpeas, and the sole crops as a control with maize spacing of 90 by 60 and cowpea and *Sonchus* at 15cm by 60cm. Plant height, % ground cover, and biomass yields were determined for each treatment. The results showed that intercropping maize with *Sonchus* was feasible where in between space was sufficient. Intercropping *Sonchus* with maize significantly improved ground cover by over 65% and resulted in significant amounts of biomass yields of over 7.5 tons/ha.

Key words: Sonchus; ground cover; biomass; maize-cowpea intercrop.

1.1 INTRODUCTION

Rain-fed agriculture plays a crucial role in food security at national and household levels in sub-Saharan Africa, but is characterized by low crop production (Cooper *et al*., 2008). Maize (*Zea mays* L.) is one*)* of the most important staple food crop in the region for more than 1.2 billion people. Maize is normally intercropped with cowpea (*vigna unguiculata* as a relay crop and many people rely on the crop as a primary source of nutrition including protein, energy and some of the important vitamins and minerals (Pswarayi and Vivek, 2004). While maize yields are poor due to declining soil fertility coupled with reduced rainfall and pests, cowpea is highly vulnerable to numerous pests, diseases and weeds resulting in low production levels. The food shortage trends have to be reversed by all means through use of appropriate improved agricultural technologies (Bruce, 2010). Use of cultural methods such as timely planting, mulching and use of cover crops has been reported to be effective in suppressing and reducing weeding costs, conservation of soil moisture and addition of organic matter upon decomposition.

Intercropping has been identified as one of the most promising options for diversification and increasing sustainability of most agricultural production systems. Intercropping helps in averting risks in case of crop failure, soil conservation and improvement of soil fertility, weed control and provide balanced diet (Lithourgidis *et al*., 2011; Odendo *et al*., 2011; Belel *et al*., 2014). Intercropping results in mutual and profitable biological relation among crops that lead to increased grain yields, increased efficiency in use of available resources and lowers weed competition (Kadziuliene *et al.,* 2009). Greater yields from intercropping have been associated with higher efficient use of PAR by the canopies, effective use of soil materials resulting from variation in depth of root system and rooting arrangement (Dapaah *et al*., 2008; Chen *et al.*, 2004; Zhu *et al*. 2007).

Sonchus is commonly found in zero or reduced tillage systems, and so occurs in both fallow and cropped areas. *Sonchus* uses valuable stored soil moisture during fallow periods, which reduces the yield of future crops (Widderick *et al.,* 2010). *Sonchus* is consumed by many people in many parts of the world as a salad vegetable and pot herb. In addition, it has many uses as human food and as medicines in Africa and Asia where it is used for feeding cattle and other livestock (PROTA, 2014). In the coastal region of Kenya, *Sonchus* commonly grows in the wilderness and is used as a vegetable and a delicacy by most communities. It is always left to grow with cultivated crops, before plucking it for consumption either as a vegetable or as feed for livestock. It is mostly preferred by other livestock especially poultry, goats and cattle than grass (Grubben and Denton, 2004). Although cowpea is used in most maize intercropping systems due to its drought tolerant characteristics, it is highly vulnerable to numerous pests, diseases and weeds resulting in low yields of both grains and leafy vegetables.

Thus, *Sonchus* regarded as a weed in most maize-cowpea intercropping systems, and widely used in most household as a leafy vegetable and animal feed can be a substitute or complement for cowpeas in meeting the nutritional requirement of the community. However, its role as a weed and a cover crop and also in reducing crop yields has not been investigated. Therefore, this study was conceived to investigate the effects of *Sonchus* on maize-cowpea cropping systems to inform its incorporation in food systems. This would also increase its adoption as an intercrop in most maize cropping systems among the small holder farmers who consider it as an important source of food, medicine and a fallback leafy vegetable.

2.0 MATERIALS AND METHODS

2.1 The experimental site

The study was conducted at Pwani University Crop Science farm in Kilifi County during the 2014 to 2016 long and short rains seasons. The site chosen was a representative of the major cowpea and maize growing regions of Coastal Kenya. Kilifi County lies between latitudes 3° S and 4° S and longitudes 39° E and 40° E, and at an altitude of about 30-50m above sea level in coastal lowland zone. The region experiences minimum and maximum mean temperatures of 26° C and 30° C, respectively and receives a bimodal rainfall of about 1100mm, with long rains falling between months of April and July, and short rains between October and December. The soils are predominantly sandy loam (mainly ferasols) characterized by low structural stability, low organic carbon, poor in plant nutrients and are sensitive to erosion.

2.2 Test materials

The test crops were maize, cowpeas and *Sonchus.* A bulking site for *Sonchus* was set near the experimental site for seed collection. Maize and cowpea varieties were selected in conformity to the environmental conditions. A drought tolerant hybrid maize variety DH04 was used and a local cowpea variety.

2.3 The experimental design and treatments

The experiments were laid out in a randomized complete block design replicated thrice. The plot sizes were 3.0 m x 3.0 m. Paths between blocks were 1.5 m wide and between plots were 1.0 m wide. The treatments represented as intercrop combinations included included: -

i) Intercrops of: maize+Sonchus; cowpea+Sonchus; maize+cowpea; maize+cowpea+Sonchus

ii) Sole crops of maize, cowpea and *Sonchus* as controls.

Thus, in the intercrops, maize and cowpeas were intercropped with *Sonchus* to quantify its effects on ground cove and yields, while the sole crops were used as controls for comparison.

2.4 Crop establishment and maintenance

Land preparation was performed two months earlier before planting to eradicate existing weeds, followed by laying out the various plots. In all plots, maize was planted at a spacing of 60 cm x 90 cm between plants and rows, respectively, at the onset of rains. Three seeds were planted in each hole and later thinned to two plants per hill. Where there was an intercrop with cowpeas or *Sonchus,* one row of the latter was planted in between two rows of maize. Seeds of local cowpea variety were planted at a spacing of 60 cm x 15 cm as a sole crop. Where there was an intercrop of cowpea with *Sonchus,* they were planted in alternating rows. Three seeds of cowpea were planted per hole and later thinned to two plants per hill. *Sonchus* sole crop was planted at a spacing similar to that of cowpeas. This arrangement allowed an equal population of maize and cowpea. Weeding was done twice, that is at two weeks and six weeks after planting. Planting fertilizer (Di-ammonium phosphate, DAP) for maize was applied at a rate of 50kg/ha g. Insect pest control was done using Jackpot insecticide at the rate of 15 ml per 20 litres of water. Jackpot 50 EC is a broad spectrum synthetic pyrethroid for the control of biting and sucking insect pests. The active ingredients are imildachlorid and alpha-cypermethrin. Supplementary irrigation was done during the dry spell.

2.5 Data collection

The data collected included: yield components of maize and cowpeas such as maize grain field weight, maize stover weight and number of cobs; maize height, growth rate of maize (height);

cowpea grain yield, cowpea biomass weight, *Sonchus* fresh weight biomass, and ground cover for all the crops. In this manuscript we report the groundcover (%) trait only. Percentage ground cover was measured using the string and dot method as described by Sarrantonia (1991). The string measuring 10 m was marked with beads at a space of 10 cm and was stretched diagonally on each plot and counts of beads under which there was a leaf were made, and average of counts on the two diagonals were determined. The average counts of beads were expressed as a percentage of the total number of beads on the string to get percentage groundcover. Percent groundcover was calculated as: number of beads under plant cover divided by total number of beads across plot diagonal multiplied by 100.

2.6 Data Analysis

The data was subjected to analysis of variance (ANOVA) using statistical analysis software (SAS) and means separation were done using least significant difference (LSD) at 5% significance level.

3.0 RESULTS

3.1 Effects of intercropping *Sonchus,* maize and cowpeas on ground cover

The results indicate that significant differences in ground cover ($P \leq 0.05$) were observed among the different treatments (Table 1) in each season. All the treatments that had cowpea as a component in intercrop combination resulted in comparable ground cover (%). Higher (%) ground cover was generally observed in the intercropped treatments compared to sole crop treatments, except for cowpea sole crop treatments.

Table 1: Ground cover (%) in different cropping treatments in 2014/2015 long and short rains

	Six weeks after planting		Seven weeks after planting		Eight weeks after planting	
Treatment	**Long rains**	**Short rains**	**Long rains**	**Short rains**	**Long rains**	**Short rains**
MA	30.76c	25.7c	40.2c	40.0b	43.03c	46.5b
MA+SO	50.67b	53.1b	68.77b	63.4a	63.57b	86.5a
MA+SO+CO	68.73a	65.3a	78.33a	74.4a	80.57a	76.5a
MA+CO	71.53a	67.95a	74.3ab	70.6a	78.77a	74.8a
CO	76.77a	72.93a	82.9a	78.8a	82.17a	79.4a
Mean	59.69	57.00	68.90	65.44	69.62	72.74
CV	8.27	2.92	6.3	19.3	7.1	6.5
P Value	<0.0001	<0.001	<0.0001	< 0.001	0.0002	0.007

MA= Maize sole planted; MA+SO= Maize + *Sonchus* intercropped; MA+CO= Maize intercropped with Cowpeas; MA+SO+CO= Maize intercropped with *Sonchus* and Cowpea.

During the sixth week after planting, in both the long and short rains seasons, the intercrops of maize-*Sonchus*-cowpea (MA+SO+CO treatment); maize-cowpea (MA+CO treatment) and cowpea sole crop (CO treatment) resulted in the highest ground cover (%) of more than 65% (Plate 1). The intercrops where cowpea was a component, the ground cover was significantly higher. The maize sole crop had significantly ($P \leq 0.05$) lower ground cover (%) of 30.7% and 25.7% during the long and short rain seasons, respectively. The maize-*Sonchus* intercrop (MA+SO treatment) had second highest ground cover (%) of 50.6% and 53.1% during long rain and short rain seasons, respectively. The maize-*Sonchus* intercrop had significantly lower ground cover (%) compared to other intercrops and sole cowpea, but higher than that of sole maize crop (Figure 1). The ground cover of maize-*Sonchus* intercrop remained fairly constant throughout the growing period ranging from 39.3% at sixth week to 46.2% at the eighth week.

During the seventh week after planting in both seasons, there were no significant differences in ground cover (%) among the intercropped treatments that had cowpea. However, maize sole crop had the lowest ground cover (%) of 40% in both seasons compared to all other treatments while maize –*Sonchus* intercrop had the second highest significant ground cover (%) after treatments that has cowpea (Figure 1). At the eighth week after planting, treatments with cowpea as a component had comparable ground cover (%). In both long and short rain seasons, during the eighth week, maize sole crop had the lowest ground cover of 43% and 46% respectively. However, in the eighth week, all the treatments in the short rain season had comparable ground cover (%) except the sole maize crop that had the lowest ground cover of 46.5%.

Maize-cow pea intercrop cover | maize-*Sonchus* intercrop cover

Plate 1: Fully covered ground by the different intercropping treatment components

3.2 Biomas of *Sonchus* under different cropping systems

The harvestable biomass of *Sonchus* under different cropping systems was similar during long and short rain seasons (Table 2). The results showed that the biomass of *Sonchus* was highest under sole cropping than when intercropped with either maize or cowpeas. The second highest biomass of *Sonchus* was observed in maize-*Sonchus* intercrop where 10-12.5 tons/ha of *Sonchus* biomass was realized (Table 2). The lowest biomass production of 2.5-2.78 tons was observed in the *Sonchus*-cowpea intercrop a reduction between 84-82 % compared to the other treatments.

Table 2: Biomass of *Sonchus* (t/ha) in the different cropping systems

	Long rain season 2014/2015	Short rain season 2014/2015
Treatment	**Biomass (t/ha)**	**Biomass (t/ha)**
SO+CO	2.78a	2.58a
MA+SO	10.36b	12.52b
SO	17.83c	14.68c
Mean	10.32	9.93
P Value	<0.001	<0.05
CV	23.71	35

Key: SO = *Sonchus* sole crop; MA+SO = Maize intercropped with *Sonchus*; SO+CO = *Sonchus* intercropped with Cowpeas.

This suggests that cowpea was vigorous in growth and this suppressed *Sonchus* growth given that it is intolerant to shading. The *Sonchus* biomass in the maize/*Sonchus* intercrop was moderately reduced resulting in about 7.5tons/ha of biomass that can be used as leafy vegetable, without significantly compromising maize yield. This implies that intercrop of maize and *Sonchus* is possible since the growth habits and canopy structures of the two crops are compatible and complement each other, where neither of the crop adversely over-shades the other and allows enough solar radiation and sharing of various resource elements efficiently.

4.0 DISCUSSION

4.1 Maize and Sonchus cropping system treatments

Sole maize crop had the lowest ground cover (%) throughout the growing period compared to all other cropping systems, suggesting that its potential to conserve soil moisture during its growth period was low. Maize growth pattern and canopy architecture is such that during its crop development stage (normally 3-4 weeks after planting), the rate of leaf production and expansion increases significantly resulting in increased leaf area index and a dense canopy (SZhang *et al*. 2004). However, as it approaches flowering and silk formation stages, the length of the internodes increases and so is the plant height. This makes the leaves appear long and narrow, thinly spread and hanging, leading to reduced ground cover and more light penetration. This explains the significantly low ground cover observed in sole maize crop.

Since light is a vital factor that determines biological yield especially when two morphologically different crops with varying periods of maturity are intercropped, the incorporation of *Sonchus* into maize intercrop significantly improved the ground cover (%). This is due to the fact that the maize leaf structure and architecture allowed more light to penetrate through and the *Sonchus* was able to make use of this light and increased its leaf canopy. These findings are in agreement with those reported by Metwally *et al.*, (2012) who observed that maize canopy architecture plays an important role in determining the amount of solar radiation intercepted by other crops planted in an intercropping system. Similar observations were also reported by Jeyakumaran and Seran (2007) and Ijoyah, (2012). This therefore explains the observed higher significant ground cover due to combined leaf area index of maize-*Sonchus* intercrop of over 40% throughout the growing period.

The enhanced groundcover (%) in the maize intercrop with *Sonchus* indicate that moisture can be retained for plant growth and thus there can be improvement in the utilization of other resources available during growth compared to sole maize crop. This implies that intercrop of maize and *Sonchus* is possible since the growth habits and canopy structures of the two crops are compatible, neither of them adversely over-shades the other and there is efficient sharing of resources. Oyewole, (2010) observed that crop biomass accumulation depended on amount of light intercepted by leaves and also on the effectiveness with which the intercepted light is used to produce dry matter. However, any influence on the plant canopy causing partial shading due to intercropping or competition for other resources can affect yield and this depends on the growth habit of crops and crops-weed competition (Dimitrios *et al.,* 2010).

4.2 Sonchus and cowpea cropping system treatments

The drastic reduction in *Sonchus* biomass in the cowpea-*Sonchus* intercrop can be attributed to shading effect and competition for growth resources since *Sonchus* is reported not tolerate shading (PROTA, 2014). This indicates that the *Sonchus* was out-competed by cowpeas in harnessing and utilization of available resources. The spreading and climbing habit of cowpeas plant probably led to reduction in the amount of light energy intercepted by *Sonchus* thus reduced reducing its photosynthetic capacity. Similar results were reported by Pandey *et al.,* (2003) whereby weed population and weed biomass in intercropping systems with cowpeas was greatly rediced. This observation also collaborates with findings by Wang *et al.,* (2006), that cowpea was an ideal cover crop in many regions due to its competitive capacity over weeds and other crops. Thus, cowpea has strong abilities to suppress weeds when used as a cover crop, intercrop, or organic mulch (Hutchinson and McGiffen, 2000; Monaco *et al.,* 2002; Ngouajio *et al.*, 2003). Jamshidi *et al.,* (2013) also showed that cowpea, acting as living mulch, reduced weed biomass by up to 45.5 % when intercropped with maize. Thus, cowpea planted in between the rows of *Sonchus* acted as a cover crop thus suppressing the growth of *Sonchus*. As such, *Sonchus* did not influence cowpea biomass since it was over taken by cowpeas due to its prolific nature.

5.0 CONCLUSION

Crop diversification underpins today's production and provides assurance and cushion against shocks, in the face of climate variability and pressure on land owing to population growth. The results clearly indicate that *Sonchus* can be intercropped with maize since it significantly improves ground cover that creates a beneficial micro-climate. The maize-*Sonchus* and cowpea-maize intercropping are more effective in improving soil water retention compared to sole maize due to the enhanced ground cover. Intercropping cowpeas with *Sonchus* is not feasible due to the aggressive growth and spreading habit of the cowpea crop. Further refined research on spacing and density for maize and *Sonchus* intercrop should be carried out to develop an agronomic package that would ensure maximum returns for promotion.

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