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Efficiency and Relative Benefit of Organic Mulches on Weed Control in Chinese Cabbage Production, A Case of Morogoro, Tanzania

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Abstract
This study presents different organic mulches' effectiveness in enhancing Chinese cabbage productivity through improved weed control in Eastern Tanzania. The experiment was conducted in the field and laid out in a Randomized Complete Block Design (RCBD). The seeds were sown on trays in the nursery and the seedlings were transplanted after three weeks. The five treatments each replicated three times treatments T1 (paddy straw mulch), T2 (Sawdust mulch), T3 (Rice husk), T4 (negative control or unweeded), and T5 (positive or weed free). Mulches were applied immediately after transplanting at a depth of 10cm. Growth, yield and weed density data were collected after four weeks of transplanting to assess the effectiveness of different mulches for weed control. The results indicated that all mulch treatments significantly reduced weed density whereby sawdust showed the most effective mulch in control of the sedge weed at 81% followed by rice husk at 79% and paddy straw at 78%. For broad-leaf weeds, rice husk was most effective as it reduced weed density by 100% followed by paddy straw by 88% and sawdust by 87%. And for grass-type weeds, the most effective mulch was rice husk 100% followed by paddy straw 88% and sawdust 87%. This improved weed control translated to better growth and higher yields of Chinese cabbage. Rice husk mulch treatments showed the high biomass with 39%. The benefit analysis revealed that while all mulches are beneficial, T1, T2 and T3 both optimize the yield of Chinese cabbage and control weeds but T3 seemed to be good in weed control and increase the yield of Chinese cabbage production.

Keywords: Chinese cabbage, Organic mulches, sawdust, rice husks, paddy straw, biomass, Tanzania

INTRODUCTION

Chinese cabbage (Brassica rapa L.) vegetables commonly grown in the world are sources of fiber. Fiber intake can help to promote healthy digestion, lower cholesterol levels, and lower incidence of cardiovascular diseases and obesity. Chinese cabbage also supplies vitamin C and is a source of phytochemicals that function as antioxidants and protect cells from damage (Slavin and Llyod, 2012). The consumption of the Chinese cabbage may prevent the occurrences of non-communicable diseases such as cancers (Karnpanit et al., 2019). It is an excellent source of folic acid important for blood formation, vitamin A, vitamin B, and mineral salts such as sodium, potassium, magnesium and calcium. In Tanzania the vegetables, including the Chinese cabbage are grown all over the place in the country due to its adaptability to various climatic conditions (Mongi et al., 2022). Chinese cabbage can grow in wide range of temperature typically 15-25°C, Tanzanian`s diverse climate of many regions is within this range. Chinese cabbage is typically grown in cool climate areas with low temperature; it is grown in some highland areas where temperature is lower and the altitude is higher. In Tanzania, highland regions have low temperature which would be favourable for growing Chinese cabbage vegetable. Also, in warmer regions Chinese cabbage is being grown. For example an average of 3.4 tons per hectare of Chinese cabbage has been reported to be produced in Dodoma city each year (Mongi et al., 2022).

Production of Chinese cabbage is faced with many problems such as insects, diseases, weeds, poor nutrients supply, change in climatic conditions, and infertile soil. These results into poor production of Chinese cabbage among small- and large-scale producers of Chinese cabbage vegetables and low quality of products (Liu et al., 2017) and (Huang et al., 2019). Despite, being faced with these problems weed is deemed to be a serious problem in Chinese cabbage production. Weed infestation is a significant challenge in Chinese cabbage (Brassica rapa L) production, causing substantial reductions in yield and quality (Mal etal., 2005). Weeds compete for essential resources such as nutrients, water, and light and can harbor insect and diseases causing pathogen, further threatening crop health. The traditional chemical herbicides, although effective, pose environmental risks and are unsuitable for organic farming (Horn et al., 1987; Greenlife, 2024). Consequently, there is increasing interest in sustainable and environmentally friendly weed management practices. Organic mulching, using materials like wood chips, compost, paddy straw, rice husks, saw dust and cover crops, offers a potential solution by suppressing weed growth, conserving soil moisture, and enhancing soil fertility. However, the comparative effectiveness of different organic mulches in controlling weeds in Chinese cabbage cultivation remains underexplored. Since weed compete with crops for resources such as water, sunlight, nutrients. Also reduce the growth of the crops, harbor dangerous insects that destroy the crops, also some weeds make difficult for crops to be harvested and finally results into loss of yield and loss of quality to the products as under water stress conditions weed can reduce crops yield more than 50% through moisture competition alone (Abouziena et al., 2016), also when left uncontrolled weed may leads to 100% total yield loss (Chauhan, 2020). Therefore, weed need to be controlled so as to prevent losses that occur due to weed infestation.

This study aimed to estimate the effectiveness of various organic mulching materials in controlling weeds in Chinese cabbage fields. Specifically, the study will compare the weed clampdown capabilities of different organic mulches and assess the impact of these mulches on Chinese cabbage growth, yield and quality. Several stakeholders, farmers and agricultural practitioners will benefit from practical insights on sustainable weed management, leading to improved yields and quality (Greenlife, 2024; Brainard & Noyes, 2022). Researchers and academicians will gain valuable data contributing to the field of sustainable agriculture (Horn et al., 1987). Policy makers and agricultural extension services can use the results to promote environmentally friendly farming practices (Greenlife, 2024). Consumers will enjoy safer and more nutritious produce due to reduced chemical herbicide use (Båth & Bäckman, 2020). Anticipated benefits include improved weed management, enhanced soil health, cost savings, and increased yield and quality. Socio-economically, this research promotes sustainable agriculture, economic viability for farmers, health and safety for communities, and potential job creation in rural areas (Horn et al., 1987; Båth & Bäckman, 2020; Greenlife, 2024).

MATERIALS AND METHODS

This research was conducted at Crop Museum located in Sokoine University of Agriculture (SUA)

Morogoro. The area is found at Latitude of 06˚S 50˚S, Longitudes37˚S 39˚ E and altitude of 525m above the sea level. Suitable soil for growing Chinese cabbage is clay loam soil with pH of 5.1 (TMA, 2017). Rainfall ranges from750-1050mm per annum and temperature ranges between 15˚C-35˚C. The duration of this research was from April 2024 to July 2024.

Chinese cabbage variety Mchihili was bought from an Agrovet shop in Morogoro Municipal. Cereal straw (Paddy straw), sawdust and rice husk to be used as organic mulching materials were collected from Morogoro municipal.

Nursery, land preparation and layout, and crop establishment single seed per cell of a tray was sown in the nursery, and seedling was spent on nursery three weeks (21 days). Land preparation was done by using a hand hoe and rake to remove weeds and other plant residues. The area then was measured and marked out using measuring tape and wooden pegs. Land was tilled to loosen soil and plots were prepared. The layout was set by length and width of 14.5m by 7.5m respectively, each plot measure 2.1m length by 1.5m width, alleys of 0.5m both within and between replication and 1m around each side experimental area was measured with the measuring tape. The experimental field was divided into 15 plots; each plot was measured to have a length and width 2.1mx 1.5m respectively, alley 0.5m between replication and between plots as a path resulting to 14.5m length by 7.5m in wide with the total area of 108.75m^2. Transplanting of seedling on experimental plots was done after 21 days from nursery establishment when seedlings are 3cm high and have 3-4 leaves. Seedling were transplanted at spacing of 30cm by 30cm, where by hole opened 2cm deep and single seedling was planted per hole and covered with soil, 5 rows of plants were planted on each plot, each row had 7 plants thus each plot contained 35 plants, making the total plant population to 525 plants/108.75m^2. Mulches were applied immediately after transplanting with 5cm was left around the plant and management kept constant on irrigation, pest and fertility management. Soil fertility was managed by application of poultry manure from chicken around the plant one week after transplanting.

The experimental design was Randomized Complete Block Design (RCBD), with five treatments each replicated three times, treatments were T1 (paddy straw mulch), T2 (Sawdust mulch), T3 (Rice husk) with 10cm thickness for all treatment and T4 (negative control or unweeded threshold) and T5 (positive or weeded).

RESULTS AND DISCUSSION

Number of Leaves

Results showed that, there was no significant difference in the number of leaves among treatments since the P-value was (0.053) greater than (0.05), the probability significant level. Moreover, there was no confidence to reject null hypothesis since F-statistic (3.74) was less than F-critical (3.84). Generally, the coefficient of variation (cv) on plant heights (9.3%) was small enough (less than 30%), indicated the low level of dispersion on number of leaves around the mean.

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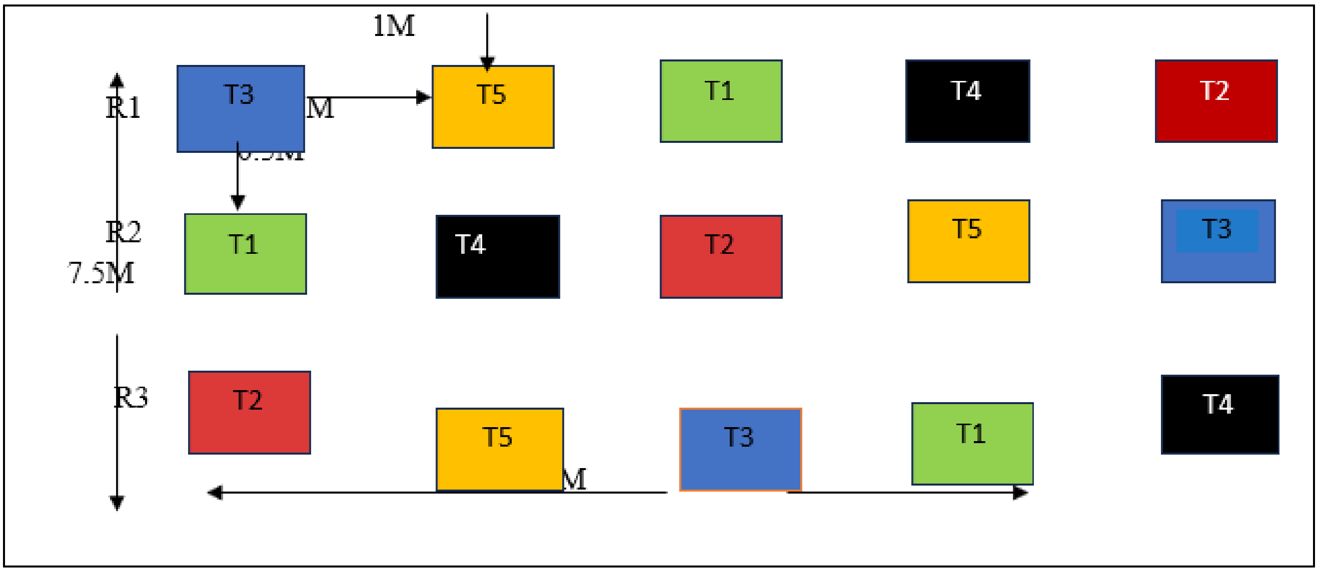
Experimental Design



Leaf Biomass

Results of statistical analysis of leaf biomass showed that, there was a highly significant difference among treatments since the P-value was (<0.001) less than (0.05), the probability significant level. Therefore, there was confidence to reject null hypothesis since F-statistic (26.23) was larger than F-critical (3.84). However, the coefficient of variation (cv) on leaf biomass (19.2%) was relatively small (smaller than 30%), indicated that there was low level of dispersion on leaf biomass around the mean. Consider the table below;

Table 1: Results of statistical analysis of leaf number and leaf biomass among treatments

Analysis of variance (ANOVA)	Leaf number	Leaf biomass (Kg)
T1 (Paddy straw)	8.333^{a}	3.367^{b}
T2 (Sawdust)	10.000^{ab}	2.800^{ab}
T3 (Rice husk)	10.667^{b}	7.333^{c}
T4 (Weedy)	8.667^{a}	1.767^{a}
T5 (Weed free)	10.667^{ab}	3.367^{b}
Grand mean	9.53	3.73
% CV	9.3	19.2
F-statistic (F-calculated)	3.74	26.23
F-critical (F-tabulated) at $P \leq 5\%$	3.84	3.84
P-value	0.053	<0.001

Plant height

Results from statistical analysis of plant heights showed that there was no significant difference among treatments since the P-value was (0.536) greater than (0.05), the probability significant level. Therefore, there was no confidence to reject null hypothesis since F-statistic (0.84) was less than F-critical (3.84). The coefficient of variation (10.3%) was small enough (less than 30%), indicated the low level of variability plant heights around the mean.

Leaf Length

Results of analysis of leaf lengths showed that there was no significant difference among treatments since the P-value was (0.378) greater than (0.05), the probability significant level. There was no confidence to reject null hypothesis since F-statistic (1.21) was less than F-critical (3.84). Also, the coefficient of variation (cv) on plant heights (7.6%) was small enough (less than 30%), indicated that there was low level of dispersion on leaf lengths around the mean.

Leaf Width

Results of analysis of revealed that there was no significant difference on leaf width among treatments since the P-value was (0.440) greater than (0.05), the probability significant level. In addition, there was no confidence to reject null hypothesis since F-statistic (1.21) was less than F-critical (3.84). Generally, the coefficient of variation (cv) on leaf widths (13%) was small enough (less than 30%), indicated that there was low level of dispersion on leaf lengths around the mean, hence practically reliable. Consider the table below;

Number of Weeds

In evaluation of population of weeds, three weed types; broad leaf, sedge and grassy weed types were recorded. The results of statistical analysis of weed types showed that, there was highly significant difference of broad leaf and grassy weed types among treatments since the P-values were (0.005) and (0.022) respectively, and all P-values were less than (0.05), the probability significant level. Therefore, there was a confidence to reject null hypothesis since F-statistics were (8.83) and (5.27) respectively, and all were larger than F-critical (3.84). In contrast, for sedge weed type, results showed that, there was no significant difference among treatments since the P-value was (0.103) greater than (0.05), the probability significant level. Therefore, there was no confidence to reject null hypothesis since F-statistic (2.77) was less than F-critical (3.84). However, the coefficients of variation (cv) of both broad leaf, sedge and grassy weed types were (100.9%), (71.6%) and (129.8%) respectively, in which all were very large (greater than 48%), indicated that there was very high level of dispersion on number of weeds around the mean and hence datasets were practically not reliable. Consider the table below;

Table 2: Results of statistical analysis of plant heights among treatments

Analysis of variance (ANOVA)	Plant height (cm)
T1 (Paddy straw)	5.333^{a}
T2 (Sawdust)	5.333^{a}
T3 (Rice husk)	5.333^{a}
T4 (Weedy)	5.333^{a}
T5 (Weed free)	6.000^{a}
Grand mean	5.47
% CV	10.3
F-statistic (F-calculated)	0.84
F-critical (F-tabulated) at P ≤ 5%	3.84
P-value	0.536

Table 3: Results of leaf lengths and leaf widths among treatments

Analysis of variance (ANOVA)	Leaf length (cm)	Leaf width (cm)
T1 (Paddy straw)	31.67[a]	15.33[a]
T2 (Sawdust)	31.67[a]	17.00[ab]
T3 (Rice husk)	30.00[a]	18.00[a]
T4 (Weedy)	30.00[a]	18.67[a]
T5 (Weed free)	33.67[a]	18.33[a]
Grand mean	31.40	17.47
% CV	7.6	13.0
F-statistic (F-calculated)	1.21	1.05
F-critical (F-tabulated) at $P \leq 5\%$	3.84	3.84
P-value	0.378	0.440

Table 4: Results of weed populations among treatments

Analysis of variance (ANOVA)	Number of weeds		
	Broader weeds	Sedge weeds	Grassy weeds
T1 (Paddy straw)	0.667[a]	23.00[ab]	0.667[a]
T2 (Sawdust)	1.333[a]	19.67[ab]	0.667[a]
T3 (Rice husk)	0.000[a]	21.67[ab]	0.000[a]
T4 (Weedy)	8.667[b]	40.67[b]	5.667[b]
T5 (Weed free)	0.000[a]	0.00[a]	0.000[a]
Grand mean	2.13	21.0	198.67
% CV	100.9	71.6	129.8
F-statistic (F-calculated)	8.83	2.77	5.27
F-critical (F-tabulated) at $P \leq 5\%$	3.84	3.84	3.84
P-value	0.005	0.103	0.022

DISCUSSIONS

The results showed that the growth parameters of plant height, number of leaves, leaf length and leaf width did not show significant differences among all treatments. This indicated that weedy, weed-free conditions and all organic mulches used did not have a direct impact on these parameters on Chinese cabbage growth. During the experiment, the plants were provided with adequate water and organic nutrients, and the mulches might have helped to retain moisture and nutrients in the soil. The lack of significant difference in such growth parameters among all treatments might have been primarily influenced as by genetic factors as Chinese cabbage is a relatively fast-growing and hardy plant species that can adapt to varying environmental conditions, including the presence of weeds and different types of mulch and environmental conditions (such as sunlight, water, and nutrients), and management practices regardless of type of mulch used and level of weed suppression (Brown and Green, 2017).

Effects of different organic mulches on leaf biomass

Results of statistical analysis of leaf biomass showed that, there was a highly significant difference among treatments. The highly significant difference in leaf biomass among treatments can be attributed to the effectiveness of the different mulches in suppressing weed growth and competition. Rice husk mulch (T3) showed the highest leaf biomass followed by T5 (weed-free), T1 (Paddy Straw mulch), T2 (Sawdust mulch), and T4 (weedy condition) that showed the lowest leaf biomass due to competition from weeds for resources like nutrients, water and sunlight (Sabiha et al., 2016). Results suggested that both rice husk mulch and weed-free conditions were effective in promoting leaf biomass due to reduced competition from weeds and the benefits of organic mulching on soil fertility and moisture retention and emphasized the importance of weed control in maximizing plant growth. Paddy straw mulch and sawdust mulch had positive effects on plant biomass, although to a lesser extent. Rice husk mulch provides a better environment for plant growth by retaining soil moisture, regulating soil temperature, and providing a release of nutrients as it decomposes (Rahman et al., 2015).

Effects of different organic mulches on weed population

The number of weeds (population) in each treatment varied depending on the type of weed. Sedge weeds showed no significant difference among treatments, indicated that both paddy straw, sawdust and rice husk organic mulches used in the experiment did not have a significant impact on the growth and limited effect on sedge weed control. The ineffectiveness of these mulches against Sedge weeds can be attributed by the nature of the mulch materials and the characteristics of sedge weeds (Khan et al., 2012). Sedge weeds often have rhizomes or tubers that allow them to spread and regrow even when the top growth is removed. Paddy straw, rice husk, and sawdust are lightweight and have a loose texture, which may not form a dense enough barrier to prevent sedge weed growth and spread. Mulches with denser and heavier structures, such as plastic mulch or landscape fabric, can offer better weed suppression by limiting light penetration and space for weed growth (Smith and Jones, 2018).

In contrast, grassy and broadleaf weeds are more effectively controlled by organic mulches like paddy straw, rice husk, and sawdust due to their slower decomposition rate, dense texture and ability to suppress weed growth through blocking light and retaining soil moisture. Grasses and broadleaf weeds have shallower root systems and are less adapted to waterlogged conditions, making them more vulnerable to weed suppression by organic mulches (Assefa et al., 2010).

Grassy weeds showed a significant difference among treatments. T4 (unweeded) had a very high number of weeds, while T1 (Paddy Straw) and T2 (Sawdust) had a low number of weeds. T3 (Rice husk) and T5 (weed free) had zero number of weeds. This suggested that Paddy Straw and Sawdust mulches were effective in suppressing the growth of grassy weeds.

Broad weeds also showed a significant difference among treatments. T3 (Rice husk) and T5 (Weed free) had zero number of weeds, while T1 (Paddy Straw) and T2 (Sawdust) had a low number of weeds. T4 (Unweeded) had the highest number of weeds. This indicated that Rice husk mulch and weed-free conditions were effective in controlling the growth of broad weeds.

Overall, while paddy straw, rice husk, and sawdust were effective in controlling grassy and broadleaf weeds, they were less effective in controlling sedge weeds due to their faster decomposition rate and loose texture that could favor sedge weed growth. Generally, the results suggested that rice husk mulch was the most effective organic mulch among other mulches used for weed control and promoting plant growth in Chinese cabbage cultivation. Weed competition can significantly reduce plant biomass, emphasizing the importance of weed management in agricultural practices.

Economic benefits and availability of organic mulches

Paddy straw and rice husk mulches were locally readily available byproduct of rice production and inexpensive to obtain due to their affordability and availability. Also, sawdust mulch was as relatively inexpensive to obtain as sourced locally from sawmills and wood processing facilities. Both mulches were lightweight and easy to apply, making them a convenient option for weed control. Overall, the use of paddy straw, sawdust, and rice husk mulches in Chinese cabbage production can provide economic benefits by reducing the need for herbicide applications and manual weeding while providing effective control of weeds through forming of dense barriers that suppress most of weed growth (Srivastava et al., 2017).

Environmental benefits of organic mulches

Environmentally, both paddy straw, sawdust and rice husk mulches helped to conserve soil moisture and reduced evaporation and loss of moisture content and therefore, the need for frequent watering and promoting healthy plant growth. The decomposition of rice husk mulch added organic matter to the soil, improved soil health and fertility over time of experimental duration. Additionally, paddy straw mulch helped regulate soil temperature, keeping the soil cool in hot weather and warm in cold weather. In general, Additionally, both paddy straw, sawdust and rice husk mulches can help to suppress weed growth and conserve soil moisture, reducing the need for chemical herbicides and irrigation and promoting sustainable production of Chinese cabbage (Martins et al., 2020) and (Singh et al., 2016).

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

The results from the experiment demonstrated that rice husk mulch is the superior organic mulch for weed control of grassy and broad leaf weed types and promoting plant growth in Chinese cabbage cultivation as it effectively controls weeds and promotes high plant biomass. Farmers can incorporate rice husk mulch into their cultivation practices to improve crop yield and reduce the need for synthetic herbicides. Incorporating rice husk mulch into agricultural practices can lead to increased plant biomass and reduced weed competition. Additionally, Paddy Straw and Sawdust mulches can provide effective weed control for grassy weeds. However, it is important to regularly monitor and manage sedge weed populations, as these mulches may not be as effective against them.

Weed competition can significantly reduce plant biomass, highlighting the importance of effective weed management in agricultural practices. However, both mulches including rice husk, are less effective in controlling of sedge weed type, therefore, regular maintaining a weed-free environment can lead to effective control of sedge weeds for optimal growth of Chinese cabbage. Overall, the use of paddy straw, sawdust, and rice husk mulches in Chinese cabbage production can provide economic benefits by reducing the need for herbicide applications and manual weeding, while also benefiting the environment through improved soil health and reduced soil erosion. Farmers can choose the most suitable mulch based on availability, cost, and specific agronomic considerations in their production systems.

RECOMMENDATIONS

1. It is recommended that farmers should consider using rice husk mulch as a sustainable and effective method for weed control in Chinese cabbage cultivation.
2. Regular weeding or maintaining a weed-free environment is crucial for optimal plant biomass and yield.

3. By utilizing organic mulches effectively, farmers can reduce weed competition, promote healthy plant growth, and increase overall crop productivity in Chinese cabbage production.
4. Since organic mulches are less effective in controlling sedge weeds, these mulches should not be used for weed control in areas dominated by sedges.
5. Further research on the long-term effects of different organic mulches on Chinese cabbage cultivation is recommended for sustainable weed management practices.

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