Greener Journal of Agricultural Sciences
ISSN: 2276-7770; ICV: 6.15
Vol. 5 (1), pp. 001-013, February 2015

http://gjournals.org/GJAS

Research Article (DOI: http://doi.org/10.15580/GJAS.2015.1.091614361)

Effect of Leaf Priming Removal Level and Fertilization Rate on Yield of Tobacco in Zimbabwe

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ARTICLE INFO

Article No.: *091614361*
DOI: *10.15580/GJAS.2015.1.091614361*

Submitted: *16/09/2014*
Accepted: *27/09/2014*
Published: *05/02/2015*

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Keywords:
Tobacco, Tobacco Yield, Leaf Priming Removal

ABSTRACT

Tobacco (*Nicotiana tabacum L.*) is one of Zimbabwe's most valuable crop. It accounts for about 26 % agricultural gross domestic product and 61 % of agricultural exports. It is therefore important to work towards continuously improving its yield and quality. Leaf priming removal could improve the yield and quality of flue-cured tobacco. A field experiment was carried out at Kutsaga Research Station to investigate the possibility of improving yield and quality of cured leaf by removing the lower leaves (primings) and applying additional nitrogen to the remaining leaves. The experiment was laid out as a split plot experiment in a randomized complete block design with three replications. A plant spacing of 1.2 m between rows and 0.56 m within rows was used. All recommended agronomic practices in flue-cured tobacco production were observed except that 0, 2, 4 and 6 lowest leaves were removed and discarded at 6 weeks after planting. A supplementary ammonium nitrate side dressing was applied at topping at a rate of 0, 5, 10 and 25 kg N/ha. The removal of 4 leaves plus the addition of 10 kg N/ha at topping resulted in a 22.42 % increase in income above that obtained from the control. However, removal of 4 leaves plus excessive amounts of N (25 kg/ha) resulted in very large leaves but the saleable yield was lower than that from the control or other plots with the same priming removal level plus less additional N. The addition of 25 kg N/ha when only 2 leaves were removed produced the highest saleable yield and recorded 19.67 % yield increase above the control. Addition of 10kg N/ha when 4 leaves were removed resulted in 19.04 % yield increase above the control. The latter however had a better grade index. It was also noted that the removal of 4 leaves plus an extra 10 kg N/ha at topping and the removal of 2 leaves plus an additional 25 kg N/ha at topping resulted in a substantial increase of the saleable yield for all reaping groups. Removal of priming leaves plus the addition of supplementary nitrogen did not increase leaf expansion. It did not lower yields but it improved the quality of the cured leaf and this resulted in better income basing on the gross margin of the expanded project. It is therefore concluded that the removal of the lowest 4 leaves plus an addition of an extra 10 kg N/ha neither lowers yield nor quality but brings with it income benefits to the farmer.

INTRODUCTION

Agriculture plays a pivotal role in Zimbabwe's economy and as such, it is the backbone of the Zimbabwean economy (FAO, 1999; UN-Zimbabwe, 2010). About 70 percent of the population depends on agriculture for food, income, and employment (UN-Zimbabwe; 2010). Tobacco is an agricultural crop with an important economic role in the producing countries (Khodabandeh, 2006). The Zimbabwe Tobacco Association (2013) pointed out that revenue obtained from tobacco exports alone constituted up to 30 percent of the total revenue obtained from exports.

Due to increased prices of fuel, labour and other inputs, the cost of producing quality flue-cured tobacco has risen. Farmers therefore, need to be efficient in their production practices to attain high yields of good quality for maximum profits. Adoption of best management practices is therefore imperative for tobacco farmers to realize the highest profits.

Tobacco yield and quality is significantly influenced by agronomic practices. These include nutrient management, topping and sucker control, weeding and pest management. Nutrient management is very crucial in tobacco production since it influences yield and quality to a greater extent. Collins and Hawks (1993) reported that nitrogen is the most important plant nutrient in tobacco production. Parker (2009) also confirmed this arguing that even though nitrogen is not taken up in the highest quantities; it has a more pronounced effect on tobacco growth and quality. Nitrogen promotes fast and abundant development of aerial plant organs. The amount of nitrogen applied determines the yield and quality of the tobacco the farmer will have (Flower, 1999). Although over application of nitrogen fertilizer may increase the leaf size and the number of leaves per plant and thus increase the yield, it will however encourage the growth of suckers and thus increase production costs while at the same time reducing the quality of the cured leaf produced (Flower, 1999). Since tobacco is marketed under contract and auction systems, the price paid for that crop will also be low. On the other hand, under-application of nitrogen can result in very low yields of poor quality reducing the net income to the grower (Flower, 1999).

Lower leaf harvesting options are management tools of flue-cured tobacco that are determined by economic considerations. From studies which have been done before, it has been shown that the lowest leaves (primings) of flue-cured tobacco plant are the lowest in yield and value (Stocks, 1991). A lot of management practices have been adopted by farmers when dealing with these lower leaves in a bid to try and improve their profits. Some farmers choose not to harvest them while others prune and discard them because of their relatively low economic return (Stocks, 1991). According to North Carolina (2013) tobacco leaves have specific names depending on their stalk positions and these leaves have different physical and chemical properties. Primings and lugs offer the least flavor contribution and have the lowest nicotine content among all stalk positions (Fisher, 1999).

To enhance yield and quality of tobacco, it is necessary to investigate on the best agronomic management practices so as to maximize the returns per unit of land. This will not only benefit the farmers and the farming sector from maximum economic yield (MEY) but will also benefit the nation at large through increased revenue obtained from exporting large volumes of high quality tobacco since the country only consumes a very small percentage of the crop. This study was carried to investigate the possibility of improving yield and quality of cured leaf by removing the lower leaves (primings) and applying additional nitrogen.

MATERIALS AND METHODS

The study was carried out in an open field at Kutsaga Research Station where the soils are sandy loam derived from granite during the 2013/2014 tobacco growing season. The research station is in Natural Region II and it receives an average rainfall of around 800 mm to 1000 mm per annum. The rainfall usually occurs during a single rainy season from November to April. The site receives a mean annual temperature of 21℃ with insignificant frost occurrence in the months of June and July (Nyamapfene, 1991).

The land was early ploughed to a depth of 38 cm. Liming was done at the recommended rate after soil analysis. Ridges were made around mid-August 2013. A basal fertilizer, Compound C (6N:15P2O5:12K2O), was applied at a rate of 800 kg/ha as recommended by soil analyses. Seedlings of the variety KRK26 were transplanted on 25 September 2013. The variety KRK 26 is a fast ripening and one of the most popular cultivar in Zimbabwe. Recommended herbicides, pesticides and nematicides to control weeds, insect pests and nematodes respectively were also applied as recommended.

A split plot based on randomized complete block design with three replications was used. Priming level (number of priming leaves removed) was the main plot while ammonium nitrate side dressing rate was the sub plot. There were 16 plots in each block and each plot consisted of three rows. A plot was made up of 3 rows of 32 plants each. The planting distance was 1.2 meters between rows and 0.56 meters within rows. This spacing translated to 15000 plants per hectare (TRB, 2010).

The two factors that were investigated are priming level and ammonium nitrate side dressing rate at 8 weeks after planting (WAP). Four leaf priming removal levels (0, 2, 4 and 6 leaves) at 6 WAP and four nitrogen levels (0, 5, 10 and 25 kg N/ha) at 8 WAP were investigated. Since the treatments were applied starting from 6 weeks after planting (WAP), the tobacco was planted and managed according to the recommended management practices as highlighted in the TRB flue-cured tobacco handbook (2010).

At 3 weeks after planting, the first AN side dressing was applied across all treatments at the normal recommended rate of 25 kg N/ha. At 6 weeks after planting, the priming leaves were removed according to treatment specifications. Ammonium nitrate side dressing treatments were applied soon after topping at 8 weeks after transplanting according to treatment specifications.

Harvesting and assessment was done in the middle row of each plot. 30 plants were used for this purpose. Leaf expansion and stalk height measurements were done in the field. Saleable yield (final mass after grading) and quality assessments (Grade index) were done after curing the harvested tobacco leaves. Income was also calculated using the average prices paid for each grade during the 2012/13 tobacco season. Basing on the income, gross margins were also calculated for selected treatments.

Grade index is the percentage of top grades (Khan *et al.*, 2008). This index was calculated after curing. The criteria for selection or rejection are color, elasticity, moisture contents and proper ripeness.

The statistical package, Genstat Discovery 14th Edition was used to analyse the data. All data were subjected to an analysis of variance (ANOVA) and treatment means were separated using the Least Significance Difference (LSD) test at p<0.05.

RESULTS

Effect of treatments on leaf expansion

Effect of leaf priming removal on leaf expansion

As shown in Fig. 1, there were significant differences (p<0.05) among treatment means for leaf expansion of tobacco at 2, 5 and 7 weeks after topping (WAT). There was greater leaf expansion of the third leaf from the top in treatments where no leaves were removed compared to where 6 leaves were removed. However, no significant differences (p>0.05) were observed in mean comparisons, in treatments where 2, 4 and 6 leaves were removed at 2, 5 and 7 WAT.

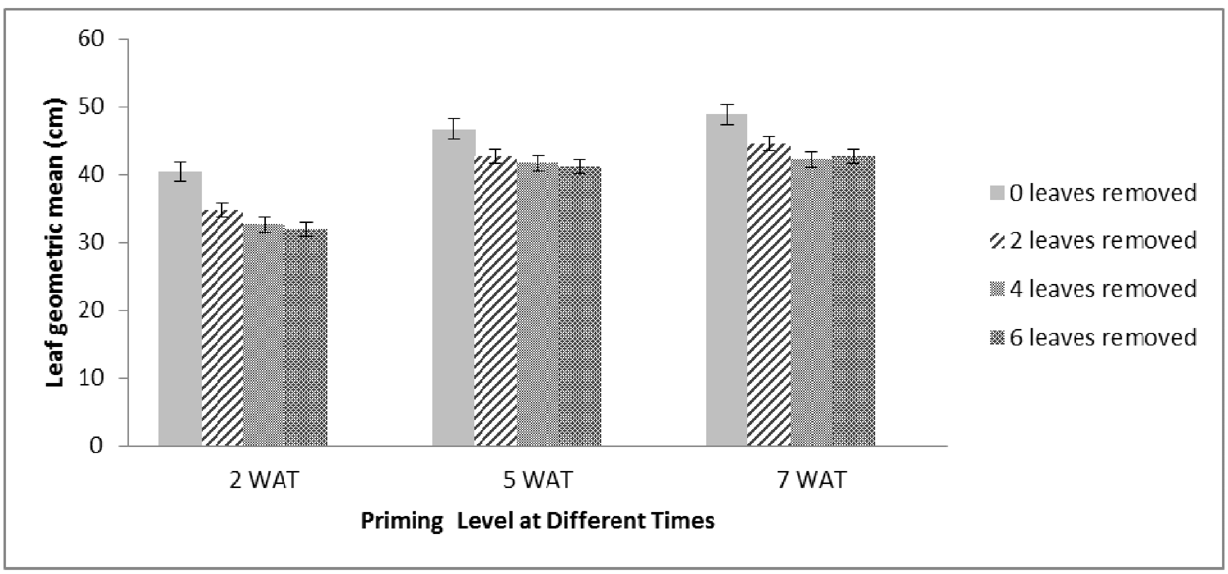

Fig. 1: Effect of leaf priming removal level on leaf expansions at 2, 5 and 7 WAT

Effect of supplementary nitrogen on leaf expansion

Different nitrogen rates resulted in significantly different (p<0.05) mean leaf expansion measurements. Plots which received 0 kg N/ha had significantly lower leaf geometric mean (LSD = 2.34) compared to the treatments that received 5 and 25 kg N/ha at 2 WAT and those that received 10 and 25 kg N/ha at 5 WAT and all other rates at 7 WAT.

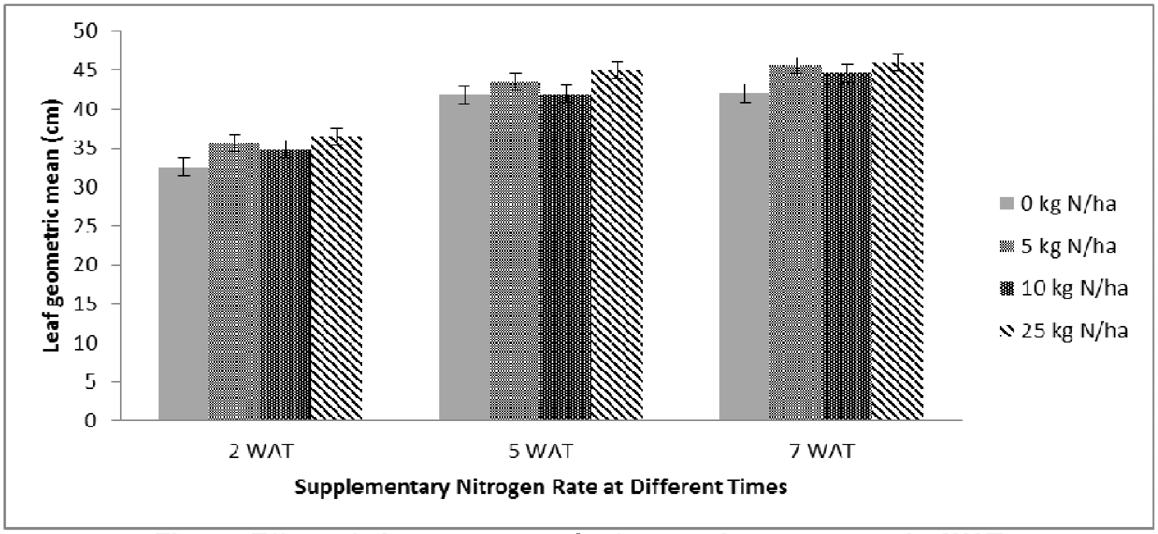

Fig. 2. Effect of nitrogen rate on leaf expansions at 2, 5 and 7 WAT

Effect of priming level and supplementary nitrogen on leaf expansion

There was no significant interaction (p>0.05) among treatment means for leaf expansion at 2, 5 and 7 WAT, although plots which received a combination of priming level 1 and 25 kg N/ha recorded the highest mean leaf expansion at 2 WAT. At 5 WAT, plots which had no lower leaves removed but received a supplementary fertilizer of 25 kg N/ha recorded the greatest leaf expansion measurement (48.61 cm) which was significantly different (LSD=4.27) from most of observations in plots where at least 2 lower leaves were removed. Plots which had 0 leaves removed and received a supplementary fertilizer of 5 kg N/ha recorded the highest mean leaf expansion at 7 WAT. This was significantly different (LSD=4.34) from most of the measurements which were recorded in the plots where lower leaves were removed.

Effect of treatments on saleable yield

Effect of leaf priming removal on saleable yield

The removal of priming leaves resulted in significantly different (p<0.05) mean saleable yield for the first reaping (Table 1). Removal of 4 leaves resulted in the least mean saleable yield for the first reaping group.

Effect of nitrogen on saleable yield

The results indicate that nitrogen rate had no significant differences (p>0.05) on the mean saleable yield for the first reaping group.

Effect of leaf priming removal level and supplementary nitrogen rate on saleable yield

The removal of 6 leaves combined with 25 kg N/ha resulted in the least saleable yield (Table 2) for the first reaping group which was significantly different (LSD=72.10) from that obtained after neither removing any leaves nor adding any extra nitrogen (Table 2). Removal of 2 leaves together with the addition of 10 kg N/ha resulted in the greatest quantity of saleable yield for the first reaping group which was significantly different (LSD=151) from the control (Table 2).

There were no significant differences (p>0.05) resulting from the interaction between priming level and supplementary nitrogen rate on all reaping groups on saleable yield (Table 3). The removal of 2 leaves together with the addition of 10 kg N/ha resulted in the greatest quantity of saleable yield for the first reaping group which was significantly different (LSD=151) from the plots which had a supplementary 10 kg N/ha but without any leaves removed, the control (Table 2). The removal of 2 leaves together with the addition of 10 kg N/ha however did not produce the highest saleable yield when all reaping groups were combined (Table 3). Table 3 also reveals that the same priming level combined with 25 kg N/ha produced the highest saleable yield (2218.67 kg/ha) when all reaping groups were combined. However, there was no significant difference (LSD=553) between this yield and that which was obtained when 10 kg N/ha was combined with the same priming level. When all reaping groups were put together, no significant differences (LSD=596.96) on mean saleable yield were observed for priming removal level x nitrogen rate except for treatments with no leaf priming removal combined with 25 kg N/ha which produced a yield of 1580 kg/ha (Table 3).

Table 1: Effect of priming level on saleable yield (kg/ha).

Priming Level	Reaping Group 1	2	3	All Groups
0 leaves removed	224.33^{BC}	349.50^{A}	1185.42	1759.25
2 leaves removed	302.00^{C}	474.42^{AB}	1224.75	2001.17
4 leaves removed	156.17^{AB}	533.00^{B}	1191.83	1881.00
6 leaves removed	76.33^{A}	585.00^{B}	1122.33	1783.67
$LSD_{0.05}$	103.9	163	352.3	426.2
P value	*	ns	ns	ns
CV (%)	27.4	16.8	14.9	11.5

* denote significance at P < 0.05; ns denotes non-significance at P>0.05. Means not sharing a common letter in a column differ significantly at 0.05 probability level.

Table 2: Mean saleable yield (kg/ha) for the first reaping group as affected by leaf priming removal level and nitrogen rate.

Supplementary Nitrogen Rate	Priming Level (Number of leaves removed) 0	2	4	6
0 kg N/ha	255.67^{aA}	207^{aA}	127.67^{aA}	124.0^{aA}
5 kg N/ha	269.67^{bA}	283^{bAB}	166^{abA}	48.33^{aA}
10 kg N/ha	130.33^{aA}	404^{bB}	235^{aA}	96.0^{aA}
25 kg N/ha	241.67^{bcA}	314^{cAB}	96^{abA}	37.0^{aA}
LSD1	151.60			
LSD2	144.10			
P value	ns			
CV (%)	27.40			

ns denotes non-significance at P>0.05. Means not sharing a common big letter in a column differ significantly at 0.05 probability level. Means not sharing a common small letter in a row are significantly different at 0.05 probability level. LSD1 is for separating means from different priming level while LSD2 is for separating means within the same priming level.

Table 3: Mean saleable yield (kg/ha) for all reaping groups as affected by leaf priming removal level and nitrogen rate.

Supplementary Nitrogen Rate	Priming Level (Number of leaves removed) 0	2	4	6
0 kg N/ha	1888	1853.00	1579.33	1829.67
5 kg N/ha	1715	2029.67	2059.67	1969.00
10 kg N/ha	1854	1903.33	2207.00	1669.33
25 kg N/ha	1580	2218.67	1678.00	1666.67
LSD1	596			
LSD2	553			
P value	ns			
CV (%)	17.7			

ns denotes non-significance at P>0.05. LSD1 is for separating means from different priming level while LSD2 is for separating means within the same priming level.

Effect of treatments on Grade Index

Effect of leaf priming removal level on Grade Index

Different levels of leaf removal significantly (p<0.05) affected grade index (Table 4). The highest grade index was obtained by removing 4 leaves for all reaping groups combined. Although there were no significant differences (LSD=7.55) on grade index values among plots which had 2, 4 and 6 leaves removed for reaping group 1, the control was however significantly different (LSD=7.55) from all the other treatments (Table 4).

Effect of nitrogen rate on Grade Index

The results showed that supplementary nitrogen rate significantly (p<0.05) influenced the grade index for the third reaping group as well as the grade index of the combined reaping groups (Table 5). However, there were no significant differences (p<0.05) on grade index values for the first and second reaping groups (Table 5).

Table 4: Effect of priming level on grade index

	Reaping Group			
Priming Level	1	2	3	All Groups
0 leaves removed	40.04^{A}	62.96	51.69	52.90^{A}
2 leaves removed	47.44^{AB}	66.48	52.55	55.43^{AB}
4 leaves removed	50.35^{B}	66.39	54.70	57.86^{B}
6 leaves removed	52.06^{B}	64.11	53.91	57.18^{B}
$LSD_{0.05}$	7.55	5.43	3,50	2.54
P value	*	Ns	ns	*
CV (%)	8.0	4.2	3.3	2.3

* denote significance at P < 0.05; ns denotes non-significance at P>0.05. Means not sharing a common letter in a column differ significantly at 0.05 probability level.

Table 5: Effect of nitrogen rate on grade index

Supplementary	Reaping Group			
Nitrogen Rate	1	2	3	All Groups
0 kg N/ha	47.26	65.83	56.91^{B}	58.70^{B}
5 kg N/ha	46.22	67.49	51.93^{A}	55.35^{A}
10 kg N/ha	48.24	62.81	50.58^{A}	53.99^{A}
25 kg N/ha	48.17	63.82	53.42^{A}	55.32^{A}
$LSD_{0.05}$	5.73	4.22	3.25	2.25
P value	ns	ns	*	*
CV (%)	14.3	7.7	7.3	4.8

* denote significance at P < 0.05; ns denotes non-significance at P>0.05. Means not sharing a common letter in a column differ significantly at 0.05 probability level.

Effect of priming level x nitrogen rate on Grade Index

The effects of priming level x supplementary nitrogen rate on grade index of different reaping groups are shown in Table 6, Table 7, Table 8 and Table 9 below.

Significant difference (p<0.05) were observed on grade index of the tobacco due to the different levels of leaf removal and nitrogen rate. However, for the first reaping group, the highest grade index value was obtained when 6 leaves were removed without an addition of an extra fertilizer (Table 6).

The removal of 2 leaves combined with the addition of 5 kg N/ha and removal of 2 leaves without the addition of an extra fertilizer resulted in the highest grade index values for the second and third reaping groups respectively (Table 7 and Table 8).

The removal of 2 lower leaves combined with the addition of 10 kg N/ha produced the least grade index (42.67) for the third reaping group (Table 8) which was significantly different (LSD=6.51) from the 64.71 which was obtained when a similar number of lower leaves was removed but without the addition of nitrogen (Table 8).

When yield from all reaping groups was combined, the highest grade index value was obtained from plots that had 2 priming leaves removed without the addition of extra nitrogen (Table 9).

Table 6: Mean values of grade index for the first reaping group as affected by leaf priming removal level and nitrogen rate.

Supplementary Nitrogen Rate	Priming level (Number of leaves removed)			
	0	2	4	6
0 kg N/ha	41.59^{aA}	41.28^{aA}	48.38^{abA}	57.77^{bA}
5 kg N/ha	43.25^{aA}	45.75^{aAB}	49.36^{aA}	46.53^{aA}
10 kg N/ha	37.38^{aA}	54.64b^{AB}	50.01^{bA}	50.92^{bA}
25 kg N/ha	37.95^{aA}	48.08^{aB}	53.65^{bA}	53.01^{bA}
LSD1	11.69			
LSD2	11.47			
P value	ns			
CV (%)	7.3			

ns denotes non-significance at P>0.05. Means not sharing a common big letter in a column differ significantly at 0.05 probability level. Means not sharing a common small letter in a row are significantly different at 0.05 probability level. LSD1 is for separating means from different priming level while LSD2 is for separating means within the same priming level.

Table 7: Mean values of grade index for the second reaping group as affected by leaf priming removal level and nitrogen rate.

Supplementary Nitrogen Rate	Priming Level (Number of leaves removed)			
	0	2	4	6
0 kg N/ha	70.3^{aB}	66.18^{aA}	63.31^{aA}	63.52^{aA}
5 kg N/ha	65.38^{aA}	70.33^{aA}	69.41^{aA}	64.83^{aA}
10 kg N/ha	59.09^{aA}	65.04^{aA}	64.97^{aA}	62.13^{aA}
25 kg N/ha	57.06^{aA}	64.39^{abA}	67.86^{bA}	65.96^{abA}
LSD1	8.56			
LSD2	8.45			
P value	ns			
CV (%)	7.7			

ns denotes non-significance at P>0.05. Means not sharing a common big letter in a column differ significantly at 0.05 probability level. Means not sharing a common small letter in a row are significantly different at 0.05 probability level. LSD1 is for separating means from different priming level while LSD2 is for separating means within the same priming level.

Table 8 Mean values of grade index for the third reaping group as affected by leaf priming removal level and nitrogen rate.

Supplementary Nitrogen Rate	Priming Level (Number of leaves removed)			
	0	2	4	6
0 kg N/ha	50.93^{aA}	64.71^{bC}	54.94^{aA}	57.05^{aA}
5 kg N/ha	51.31^{aA}	51.37^{aB}	53.43^{aA}	51.61^{aA}
10 kg N/ha	53.64^{bA}	42.67^{aA}	54.47^{bA}	51.54^{bA}
25 kg N/ha	50.86^{aA}	51.44^{aB}	55.95^{aA}	55.42^{aA}
LSD1	6.30			
LSD2	6.51			
P value	ns			
CV (%)	7.7			

ns denotes non-significance at P>0.05. Means not sharing a common big letter in a column differ significantly at 0.05 probability level. Means not sharing a common small letter in a row are significantly different at 0.05 probability level. LSD1 is for separating means from different priming level while LSD2 is for separating means within the same priming level.

Table 9: Mean values of grade index for all reaping groups as affected by leaf priming removal level and nitrogen rate.

Supplementary Nitrogen Rate	Priming Level (Number of leaves removed)			
	0	2	4	6
0 kg N/ha	54.09^{aA}	62.61^{bB}	58.34^{abA}	59.76^{abB}
5 kg N/ha	53.58^{aA}	54.39^{abA}	58.03^{bA}	55.39^{abAB}
10 kg N/ha	54.06^{abA}	50.65^{aA}	56.51^{bA}	54.74^{abA}
25 kg N/ha	49.87^{aA}	54.05^{bA}	58.54^{cA}	58.83^{cAB}
LSD1	4.41			
LSD2	4.51			
P value	0.018			
CV (%)	7.7			

Means not sharing a common big letter in a column differ significantly at 0.05 probability level. Means not sharing a common small letter in a row are significantly different at 0.05 probability level. LSD1 is for separating means from different priming level while LSD2 is for separating means within the same priming level.

Effect of treatments on Gross margins

Gross margin for each grade was calculated as mean revenues less the variable costs using the following formula;

GM = GI – TVC
Where GM = Gross margin,
GI = Gross income
TVC = Total variable Cost

Effect of leaf priming level on Income

Based on the average prices paid for each grade index during the 2012/13 tobacco season, the results showed that the highest mean income for the first reaping group

(US$ 928.64) was obtained by removing 2 priming leaves while the lowest was obtained when 6 leaves were removed (Table 10).

Effect of nitrogen rate on Income

It is clear from Table 4.5.2 that when considering the income obtained from the combined reaping groups, plots which received the highest nitrogen rate obtained the least income (Table 11).

Effect of priming level x nitrogen rate on Income

Based on the average prices paid for each grade index in the 2012/13 tobacco season, the treatments fetched different amount of income. For the first reaping group, removal of 2 priming leaves plus 10 kg N/ha received the highest monetary value (US$ 1399.69) which was also high than that obtained from the control (Table 12).

Comparison of grand mean income per hectare showed that removal of 4 leaves plus 10 kg N/ha had the highest income (US$ 8004.94) while the lowest income (US$ 5068.76) was obtained from the plots where priming leaves were not removed but an additional 25 kg N/ha was added (Table 13). The income that was received when excessive amounts of fertilizer was applied was lower than that obtained at moderate rates at all priming levels except when 2 leaves were removed.

Gross margin of the extended project (Table 14) shows that the removal of 4 leaves plus an addition of an extra 10 kg N/ha resulted in the best income (US $ 7874.66). It yielded 21.21 % income increase above the control which is a substantial amount to the farmer. A 15.73 % and 5.10 % income increase above the control was also observed in treatments where 2 leaves plus an additional 25 kg N/ha were removed and 6 leaves plus an additional 5 kg N/ha respectively (Table 14).

Table 10: Effect of priming level on income (US $)

	Reaping Group			
Priming Level	1	2	3	All Groups
0 leaves removed	610.24	1452.97	3924.83	5988.04
2 leaves removed	928.64	1982.15	4140.86	7051.65
4 leaves removed	516.66	2263.79	4096.07	6876.51
6 leaves removed	259.51	2374.23	3889.61	6523.35

Table 11: Effect of nitrogen rate on income (US $/ha)

Supplementary	**Reaping Group**			
Nitrogen Rate	1	2	3	All Groups
0 kg N/ha	556.73	2308.52	3790.31	6655.56
5 kg N/ha	539.68	2376.55	3874.55	6790.79
10 kg N/ha	723.31	1898.40	4049.62	6671.32
25 kg N/ha	495.32	1489.66	4336.90	6321.88

Table 12: Effect of priming level x nitrogen rate on income (US $/ha) of the first reaping group

Supplementary Nitrogen Rate	Priming Level (Number of leaves removed)			
	0	2	4	6
0 kg N/ha	752.78	571.58	413.51	489.05
5 kg N/ha	730.79	795.23	492.50	140.21
10 kg N/ha	360.46	1399.69	847.01	286.06
25 kg N/ha	596.92	948.06	313.61	122.71

Table 13: Effect of priming level x nitrogen rate on income (US $/ha) of all reaping groups

Supplementary Nitrogen Rate	Priming Level (Number of leaves removed)			
	0	2	4	6
0 kg N/ha	6550.19	7406.30	5903.42	6762.32
5 kg N/ha	5794.41	6951.18	7469.51	6948.04
10 kg N/ha	6538.80	6169.74	8004.94	5971.8
25 kg N/ha	5068.76	7679.38	6128.18	6411.22

Table 14: Gross Margin of the expanded project

Treatment combination	Control (P1xF3)	P2 x F4	P3 x F3	P4 x F2
Average yield (kg/ha)	1854.00	2218.67	2207.00	1969.00
Gross income basing on quality (US $/ha)	**6538.80**	**7679.38**	**8004.94**	**6948.04**
Variable cost for priming removal and additional fertilizer				
Cost of removing priming leaves	0.00	88.00	88.00	88.00
Cost of supplementary nitrogen	20.28	50.72	20.28	10.14
Cost of applying supplementary nitrogen	22.00	22.00	22.00	22.00
Total variable costs of the expanded project	**42.28**	**160.72**	**130.28**	**120.14**
Gross Margins for the expanded project	**6496.52**	**7518.66**	**7874.66**	**6824.90**
Additional gross margin above the control associated with treatments (US $/ha)	**----------**	**1022.14**	**1378.14**	**331.38**

NB* All figures except for yield figures are in US dollars.

DISCUSSION

Mean Leaf expansion

Leaf size is very important to cigarette manufacturers because it affects the lamina to stem ratio. A high ratio of lamina to stem is desirable in manufacturing cigarettes (Edwards, 2005). In this experiment, plots in which the lower leaves were removed recorded the least leaf expansion measurements (Fig. 1). This difference can be attributed to differences in times of topping of the treatments. The more the number of leaves removed, the smaller was the mean leaf expansion measurement at 2, 5 and 7 WAT. In plots where no lower leaves were removed, topping was done

earlier than in the other plots where pruning of priming leaves was done. After pruning of the primings, there was need to wait for the plants to have eighteen leaves before topping could be done. Therefore, those which did not have any leaves removed were topped first followed by those with only two leaves removed then those with four leaves removed and finally those with six leaves removed.

The plots that did not have any leaves removed recorded the largest leaf sizes as a result of early topping and thus the leaves started receiving more nutrients before the other treatments were topped. This is in line with the idea that topping affects the nutrient source-sink relationship of tobacco (Pandeya*et al.,* 2001; Wang *et al.,* 2012) and the suggestion that maximum leaf expansion is achieved after topping (Singh *et al.,* 2000; Hao and Chao Yang, 2001; Roton *et al*., 2005; Reed *et al*., 2012). Topping switches the plant from a reproductive phase to a vegetative phase (Pandeya *et al.,* 2001; Wang *et al.,* 2012) resulting in nutrients being channeled towards the development of leaves. Maximum leaf expansion is attained after topping and this results in an increase in leaf size and weight (Singh *et al.,* 2000; Hao and Chao Yang, 2001, Roton *et al*., 2005; Reed *et al*., 2012).

This difference in leaf sizes can also be as a result of the shape of the tobacco plant. The tobacco plant is conical in shape with a wider base and a narrow top as you approach the apical meristem (North Caroline, 2013). The uppermost leaves therefore have smaller surface area compared to the lower leaves. In this study the leaf area decreased with an increase in priming removal level. Addition of an extra N could not compensate for the leaf expansion. The differences in leaf expansion measurements can therefore be attributed to this conical shape of the tobacco plant since the treatments that were pruned resembled higher topping in the non-primed control.

Results from this study are in contrast with Edwards (2005) who pointed out that leaf size can be used as a good predictor of yield. He suggested that, the larger the leaf area and thickness, the higher the yield. In this study, the control plus an additional 25 kg N/ha produced the largest mean leaf expansion measurement at 7 WAT. However, after curing, this treatment had the least salable yield (Table 3). This is in agreement with findings by Peterson (1960) who also found that increased nitrogen rate increased leaf area and ratio of width to length of individual leaves while dry weight per unit area and thickness of the leaf was reduced. It is therefore clear that an excessive amount of nitrogen negatively affects the cured weight although they encourage leaf expansion. Collins and Hawks'(1993) also reported that an increase in the supply of nitrogen from deficient to excessive resulted in an increase in leaf size and decrease body (thickness), while inadequate amount produced smaller leaves of a lower-quality leaf.

Saleable yield, Grade Index and Income

Tso (1990) pointed out that tobacco yield and quality is influenced by many factors including fertilization. In this study the effect of removing priming leaves on yield and quality was studied together with the effect of adding additional nitrogen. The results from plots where four leaves were removed in this study were in conformity with the findings of Currin and Pitner (1980) who reported that pruning and discarding the lowest 4 leaves did not lower yields or affect the quality of the remaining leaves when compared to harvesting all leaves.

The results from this study were also in line with the report by Wolf and Gross (1937) who reported that an increase in topping height decreased leaf thickness and thus yield. Therefore when plants are topped high, there will be need for additional nitrogen to achieve the desirable leaf size. From this study, this is very clear in plots where 4 leaves were removed and thus topping was high. Removal of 4 leaves without adding an additional N resulted in a low salable yield (Table 3) which was lower than that of the control (P1 x F3) as well as that obtained from the same priming removal level plus an additional N. This is also in conformity with the report by Collins *et al.,* (1969) who also reported that at a higher topping height, yields were greater for the recommended rate of nitrogen plus 22 kg N/ha than where the recommended rate was applied.

Removal of 4 leaves plus excessive amounts of N (normal rate plus 25 kg/ha supplementary fertilizer) resulted in very large leaves but the saleable yield was lower than that from the control or other plots with the same priming removal level plus less addition N (Table 3) because excessive rates of N increases leaf area while leaf thickness is decreased and thus yield is reduced (Peterson, 1960).

While Edwards (2005) pointed out that compared to the control; removal of either 4 or 8 leaves did not affect grades or price per kilogram enough to compensate for the yield loss, the findings of this study indicates that removal of 4 leaves plus an addition of 10 kg N/ha was the best treatment as it resulted in a 21.21 % income increase above the control (Table 13). Also the removal of 6 leaves plus an addition of 5 kg N/ha generated a 5.10 % income increase above the control (Table 13). These differences in the results from these two studies can be attributed to the lack of additional nitrogen and not replacing the removed lower leaves with upper leaves by Edwards (2005). Court and Hendel (1989) also pointed out that lower leaf removal has a negative impact on yield when addition of upper leaves is not imposed.

In this study, when 4 leaves were removed (topping was therefore higher) and no additional N was added, the yield was lower than that of the control (Table 3). This is in line with Court and Hendel (1989) who also pointed out that lower leaf removal has a negative impact on yield when addition of upper leaves is not imposed.

It was also noted that the removal of 4 leaves plus an extra 10 kg N/ha above the recommended rate and the removal of 2 leaves plus an additional 25 kg N/ha on top of the recommended rate resulted in a substantial increase of the saleable yield for all reaping groups (Table 3). Although the yield increase was not significantly different ($p>0.05$), the removal of 4 leaves plus an extra 10 kg N/ha above the recommended rate resulted in a 21.21 % income increase above that obtain from the control (Table 4.5.1). This is again in conformity with the findings by Wolf and Gross (1937) and Collins *et al.,* (1969) who concluded that at a higher topping height, yields were greater for the recommended rate of nitrogen plus 22 kg N/ha than where the recommended rate was applied.

Addition of 25 kg N/ha when only 2 leaves were removed produced the highest saleable yield (Table 3) and recorded 19.67 % yield increase above the control. Addition of 10kg N/ha when 4 leaves were removed resulted in 19.04 % yield increase above the control. The latter however had a better grade index value (Table 9) and thus it fetched a higher income than the former. Parker (2009) also suggested that, excessive nitrogen had a negative effect on tobacco quality because as total N in the plant increases above the amount required for maximum growth, quality of flue-cured tobacco tends to decrease. Other earlier studies also indicated that nitrogen fertilizer consumption increases crop production and nitrogen compounds. Using excessive amounts does have negative effect on yield and decreases the quality of flue-cured tobacco (Sazgar, 1991).

It was also noted in this study that the removal of priming leaves and addition of supplementary nitrogen resulted in lower yields of very high grades for the first reaping group. Although there were no significant differences among treatment means on salable yield, there were indeed some significant differences ($p<0.05$) on the grade index values. Stocks (1991) also pointed out that the lowest leaves on tobacco plants are the lowest in yield, quality and thus value. Thus a higher grade index for the primed treatments could be attributed to the removal of the poor quality lower leaves.

Gross margin of the expanded project

With reference to the gross margin of the expanded project (Table 14), it has been noted from the selected treatments that removal of 4 leaves plus the addition of an extra 10 kg N/ha resulted in the best income (US $ 7874.66). It yielded a good 21.21 % income increase (US $ 1378.14 per hectare) above the control which is a substantial amount to the farmer even though there were no significant yield differences. A 15.73 % and 5.10 % income increase above the control was also observed in treatments where 2 leaves plus an additional 25 kg N/ha were removed and 6 leaves plus an additional 5 kg N/ha respectively. This makes the removal of 4 lowest leaves plus the addition of a supplementary 10 kg N/ha the best treatment. Currin and Pitner (1980) argued that pruning and discarding the lowest 4 leaves did not lower yields or affect the quality of the remaining leaves when compared to harvesting all leaves.

Basing on the gross margin of the expanded project, it is therefore clear that the removal of the lowest 4 leaves plus an addition of an extra 10 kg N/ha does not lower yield or quality but brings with it income benefits to farmer instead.

Priming removal reduces operational costs. It will reduce labour requirements for reaping, curing and handling costs as well as storage and transport costs among other costs for the first reaping. It will also increase the farmer's returns per unit area since the harvested leaves will be of higher quality and weight and generally fetch good prices on the market.

CONCLUSIONS

Removal of priming leaves plus the addition of supplementary nitrogen did not increase leaf expansion. It did not lower yields but it improved the quality of the cured leaf and this resulted in better income basing on the gross margin of the expanded project.

Although no significant yield differences were noted, the removal of 4 priming leaves combined with the addition of an extra 10 kg N/ha on top of the recommended rate increased the saleable yield and grade despite the plants recording smaller leaf expansion measurements as compared to other treatments where priming leaves were not removed. The removal of 4 priming leaves combined with the addition of an extra 10 kg N/ha on top of the recommended rate resulted in a better income as a result of improved grades.

Although the addition of 25 kg N/ha to treatments where 2 leaves were removed produced the highest saleable yield, it did not fetch the best market price because of lower grade index value. The income obtained from that combination was lower than that obtained from treatments where 4 leaves were removed plus an addition of 10 kg N/ha.

Basing on the gross margin, it can therefore be concluded that the addition of 10 kg N/ha after the removal of 4 lowest leaves in KRK 26 tobacco variety produces a yield of higher grade index which will fetch a higher market value and thus increases income. This practice will also save on harvesting labour and cost for the first reaping. It also saves on barn space, energy needed for curing, grading labour and storage and transport cost for the first reaping group.

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Cite this Article: Marowa P, Mtaita TA, Rukuni D, 2015. Effect of Leaf Priming Removal Level and Fertilization Rate on Yield of Tobacco in Zimbabwe. Greener Journal of Agricultural Sciences, 5(1):001-013, http://doi.org/10.15580/GJAS.2015.1.091614361.

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