EFFECT OF DIFFERENT SPACING ON YIELD AND QUALITY OF SELECTED FLUE CURED TOBACCO VARIETIES

Abstract

In flue-cured tobacco (Nicotiana tabacum L.) production the aim is improvement of yield and quality (usability) of cured leaf. This has been achieved through development of new cultivars and adjustment of cultural practices. In Tanzania, most of the flue-cured tobacco is grown at plant spacing of 50 cm within and 120 cm between rows, i.e. at planting density of about 16,666 plants per ha. In order to determine the effect of different spacing on the selected flue cured tobacco varieties quantity and quality, field experiment was performed at Tobacco Research Institute of Tanzania (TORITA) for 2014/15 crop season. Three spacing 1.15 x 0.6 m, 1.2 x 0.46 m, 1 x 0.5 m and 1.2 x 0.5 m as a control spacing and three varieties KRK 26, CC 26, CC 35 and K 326 as control were investigated in a Split Plot Design with four replications. Spacing was the sub-plot treatment while varieties were the main plot treatment. In this study, the effect of three different spacing on three selected flue cured tobacco varieties on leaf length and width, green weight yield, dry weight yield, and average grade index was evaluated. Effect of varieties on leaf size for bottom, middle and top leaves, leaf area and dry leaf yield was significant at 5% probability level. Effect of spacing on leaf size, leaf area, dry leaf yield and grade index was non-significant at 5% probability level. The interaction between spacing (sub-plot treatments) and varieties (main plot treatments) was non-significant at 5% probability level.

Key words: Flue cured tobacco, variety, spacing, yield and quality.

INTRODUCTION

Tobacco is the world's leading non-food crop grown in all continents whereby the leading producers are China followed by USA, India, Brazil, Europe and Zimbabwe (WHO, 2004). However, low yield characterizes tobacco production especially in developing countries.

In Tanzania tobacco is produced in Iringa, Tabora, Singida, Shinyanga, Ruvuma, Katavi and Mbeya regions. It is a major cash crop for export and contributing highly to the gross domestic product (GDP). For example in 2009/2010 Tanzania earned 213,817,905.63 USD from tobacco selling (BOT, 2010).

Although the crop is of importance to the economy but its production in Tanzania has been characterized by upward and downward trends. Production per unit area is low to the extent of about 1000-1580 kg/ha (TTB 2015). Besides low production, the leaf quality has been very poor to fetch good market in the tobacco world market. The low production and poor leaf quality which results into poor leaf grade may be caused by different factors one of those factors is poor spacing with respect to tobacco variety type.

Tobacco production in Tabora is low, many factors contributes to this phenomena by which poor spacing is among the major one. Different works have been conducted on the effect of spacing on tobacco quality and quantity but yet no conclusion have been drawn on the best spacing to be used on the new introduced varieties so as to maximize production while keeping the tobacco quality as higher as possible. For example researches have shown that, nitrogen levels and spacing influences cured leaf quality and quantity in tobacco production (Patel *et al.,* 2000). Patel *et al*. (2000) also reported that narrow spacing showed significantly higher growth score than medium and wide spacing, while significantly wider leaves were noted in the wide spacing.

According to Bukan *et al*. (2010), wider spacing within rows resulted in higher yield and higher monetary value than the closer spacing. Row spacing affect yield, quality index, and specific leaf weight (Agtarap *et a.,* 1983; Sagsagat *et al;* 1984. Different studies in tobacco showed that spacing influence leaf weightyield, quality, leaf composition and monetary value (Ratales *et al*., 1984; Castilo and Sagsagat, 1983).

Another study by Retales *et al*. (1984), on the effect of spacing on tobacco yield found that row spacing influenced leaf weight yield and crop value but not the number of leaves, leaf area and grade index. Also WU Jia-chang *et al*. (2000) noted that, higher planting density contributed to increasing in tobacco leaf yield, but leaf value did not increase correspondingly. However, narrow spacing can produce higher yield than wider spacing also higher crop value was derived from narrow spacing than from the wider spacing (Castillo and Sagsagat, 1983). It is enough to that from these studies the number of plants per acre can have a substantial effect on yield per acre, yield per plant, labour requirements and barn space requirements. Therefore, the number of plants per acre affects production costs and net returns *(*Mundy and Fowlkes, 1990).

In Tanzania spacing is a problem whereby farmers use spacing which are not recommended for growing tobacco varieties which differ in terms of leaf size and area and hence poses nutrients competition which causes poor crop growth. Due to this fact a need arises to evaluate the proper and optimal spacing on the yield and quality of selected flue cured tobacco varieties which possess different phenotypic and genotypic characteristics.

General objective

- To investigate the effect of spacing on yield and quality of flue cured tobacco varieties.

Research design and data collection

Research design was a split plot design with four replications. Spacing was the sub plots while varieties was the main plots. Plot size was 6m x 8.4m making a plot area of $50.4m^{2.}$ Varieties used were KRK26, CC26 and CC 35. The spacing tested were 1.15 x 0.6 m, 1.2 x 0.5 m, 1.2 x 0.46 m and 1 x 0.5 m which gave a population of 14,492, 16,666, 18,115 and 20,000 plants per hectare respectively. The control was 1.2 x 0.5 m with K326 variety.

Data collected include leaf size (length and width) for lower, mid and upper leaves, leaf area, green and dry weight, and grade index.

Data collected was managed and analysed using Cos-tat computer program using the following statistical model:

$Y_{ij} = \mu + p_i + \tau_i + \sigma_{ij} + \beta_k + (\tau\,\beta)_{jk} + \alpha_{ik} + \varepsilon_{ijk}$

where

Y_{ij}= observation corresponding to k^{th} level of subplot factor (B), j^{th} level of main plot factor (A) and the i^{th} replication

μ = Overall mean

p_i = i^{th} block effect

τ_i = j^{th} main plot treatment effect

σ_{ij} = main plot (A) error

β_k = k^{th} subplot treatment effects

$\tau\,\beta$ = Interactions between main plot and subplot effects

α_{ik} = subplot (B) error

ε_{ijk} = random error

Table 1: Treatments tested

S/N	Sub-plot treatments	Main plot treatments
1	S1 (1.15m*0.6m)	V1 (KRK 26)
2	S2 (1.2m*0.5m)	V2 (CC 26)
3	S3 (1.2m*0.46m)	V3 (CC35)
4	S4 (1.0m*0.5m)	V4 (K 326)

NB: S stands for spacing and V for variety

RESULTS AND DISCUSSION

Leaf length and width for sub plot treatments

In tobacco marketing, leaf length is an important grade attribute. Long leaves which come from properly fertilized and well cured plants fulfil the desirable qualities which acquire high grades. In Tanzania tobacco grades (Appendix 2) are based on leaf length, leaf position on a stalk, color (orange, lemon, brown) and leaf entirety.

In this trial leaf length and width were measured and representative average leaf length and width were calculated and presented in table 2.

Top leaves

The highest average value of leaf length for top leaves was from spacing number three which was 55.58 cm followed by spacing number one which was 54.95 cm long. The shorted leaves in average came from spacing number four which was 54.21 cm long. There was no significant difference among all treatments at $P < 0.05$.

The highest average value of leaf width for top leaves was from spacing number one which was 23.42 cm followed by spacing number three which was 23.20 cm. The lowest average came from spacing number four which was 22.26 cm. There was no significant differences among all treatments at $P<0.05$.

Middle leaves

The highest average value of leaf length for middle leaves was from spacing number three which was 52.98 cm followed by spacing number two which was 52.57 cm long. The shortest leaves in average came from spacing number one which was 51.42 cm long. There was no significant difference among all treatments at $P < 0.05$.

The highest average value of leaf width for middle leaves was of spacing number three which was 25.15 cm followed by spacing number two which was 24.94 cm. The lowest average came from spacing number four which was 23.76 cm. There were no significant differences among all treatments at $P< 0.05$.

Bottom leaves

The highest average value of leaf length for bottom leaves was from spacing number three which was 32.22 cm followed by spacing number two which was 31.41 cm. The shorted leaves in average came from spacing number one which was 30.47 cm. There were no significant differences among all treatments at $P < 0.05$.

Spacing number three had the highest value of average leaf width which was 18.16 cm followed by spacing number two which was 18.06 cm. The smallest value was calculated from spacing number one which was 17.18 cm. There were no significant differences among all treatments at $P< 0.05$.

Table 2: Effect of different spacing and varieties on bottom, middle and top leaves

S/N	Sub-plot treatment	Bottom leaf (cm)		Middle leaf (cm)		Top leaf (cm)		Main plot treatments	Bottom leaf (cm)		Middle leaf (cm)		Top leaf (cm)	
		Length	Width	Length	Width	Length	Width		Length	Width	Length	Width	Length	Width
1	S1 (1.15m*0.6m)	30.47	17.18	51.42	24.88	54.95	23.42	V1 (KRK 26)	30.31 b	16.23 b	55.34 a	26.77 a	58.31 a	24.38
2	S2 (1.2m*0.5m)	31.41	18.06	52.98	25.15	55.58	23.20	V2 (CC 26)	34.38 a	20.73 a	56.37 a	26.18 a	58.49 a	24.50 a
3	S3 (1.2m*0.46m)	32.22	18.62	52.98	25.15	55.58	23.20	V3 (CC35)	32.62 a	20.38 a	50.45 b	25.93 a	53.30 b	24.18 a
4	S4 (1.0m*0.5m)	30.92	17.75	51.79	23.76	54.21	22.26	V4 (K 326)	27.72 c	14.28 c	46.59 c	19.86 b	48.96 c	18.98 b
	Mean	31.26	17.90	52.19	24.68	54.77	23.01		31.26	17.90	52.19	24.68	54.77	23.01
	LSD	1.99 Ns	1.57 Ns	2.84 Ns	1.54 Ns	2.84 Ns	1.67 Ns		1.99	1.57	2.84	1.54	2.84	1.67
	CV (%)	8.95	12.32	7.64	8.77	7.29	10.22		8.95	12.32	7.64	8.77	7.29	10.22

NB: Means followed by different letters are significantly different by Duncan New Multiple Range p<0.05, Ns = Non-significant

Leaf length and width for main plot treatments

Top leaves

The highest average value of leaf length for top leaves was from variety number two which was 58.49 cm followed by variety number one which was 58.31 cm long. The shorted leaves in average came from variety number four which was 48.96 cm long. Variety number three and four differed significantly at $P < 0.05$ also variety number three and four differed significantly with treatments number one and two at $p<0.05$.

The highest average value of leaf width for top leaves was from variety number two which was 24.50 cm followed by variety number one which was 24.38 cm. The lowest average came from variety number four which was 18.98 cm. Variety number four differed significantly with the rest of the varieties at $P<0.05$.

Middle leaves

The highest average value of leaf length for middle leaves was from variety number two which was 56.37 cm followed by variety number one which was 55.34 cm long. The shortest leaves in average came from variety number four which was 46.59 cm long. Variety number three and four differed significantly at $P < 0.05$ also variety number three and four differed significantly with variety number one and two at $p<0.05$.

The highest average value of leaf width for middle leaves was of variety number one which was 26.77 cm followed by variety number two which was 26.18 cm. The lowest average came from variety number four which was 19.86 cm. Variety number four differed significantly with the rest of the varieties at $P< 0.05$.

Bottom leaves

The highest average value of leaf length for bottom leaves was from variety number two which was 34.38 cm followed by variety number three which was 32.62 cm. The shorted leaves in average came from variety number four which was 27.72 cm. Variety number one and four differed significantly at $P < 0.05$ also variety number one and four differed significantly with variety number three and four at $p<0.05$.

Variety number two had the highest value of average leaf width which was 20.73 cm followed by variety number three which was 20.38 cm. The smallest value was calculated from variety number four which was 14.28 cm. Variety number one and four differed significantly at $P < 0.05$ also variety number one and four differed significantly with variety number three and four at

$p<0.05$.

***Effect of different spacing and flue cured tobacco varieties on leaf area, green weight yield, dry weight yield and grade indices*.**

The total plant leaf area was calculated using the following formula;

LA= a x L x W, where

LA = leaf area,

a= coefficient of leaf area for flue cured tobacco (0.64)

L= average leaf length for bottom, middle and top leaf

W= average leaf width for bottom, middle and top leaf.

The highest leaf area was obtained from spacing number three which gave an area of 3449.72 cm2, (table 2) followed by spacing number two which gave an area of 3350 cm2. The lowest leaf area was obtained from spacing number four which gave an area of 3195.03 cm2 There was no significant difference among treatments at $p<0.05$.

The highest leaf area was obtained from variety number two which gave an area of 3901.48 cm2, (table 2) followed by variety number three which gave an area of 3534.73 cm2. The lowest leaf area was obtained from variety number four which gave an area of 2359.19 cm2. Variety number two and four differed significantly at $p<0.05$ also variety number two and four differed significantly with number one and three at $p<0.05$

Table 3: Effect of different spacing and flue cured tobacco varieties on leaf area

S/N	Sub plot treatment	Leaf area (cm^2)	Main plot treatment	Leaf area (cm^2)
1	S1 (1.15m*0.6m)	3249.05	V1 (KRK 26)	3448.39 b
2	S2 (1.2m*0.5m)	3350.00	V2 (CC 26)	3901.48 a
3	S3 (1.2m*0.46m)	3449.72	V3 (CC35)	3534.73 b
4	S4 (1.0m*0.5m)	3195.03	V4 (K 326)	2359.19 c
	Mean	3310.95		3310.95
	LSD	347.18 Ns		347.18
	CV (%)	14.75		14.75

NB: Means followed by different letters are significantly different by Duncan New Multiple Range $p<0.05$, Ns = Non-significant

3.3.1 Green leaf weight yield

The highest green leaf weight yield was obtained from spacing number four (table 3) which gave a yield of 15146.59 kg/ha, followed by spacing number three which gave a yield of 13785.74 kg/ha. The lowest yield was obtained from treatment number one which gave a yield of 11765 kg/ha. The results have also revealed that the green leaf yield increased with the increase in plant population. Treatments one and four differed significantly with the rest of the treatments at $p<0.05$.

The highest green leaf weight yield was obtained from variety number two (table 3) which gave a yield of 15159.18 kg/ha, followed by variety one which gave a yield of 14168.75 kg/ha. The lowest green leaf weight yield was obtained from variety number four which gave a yield of 11401.43 kg/ha. Treatments two and four differed significantly at $p<0.05$

Table 4: Effect of different spacing and flue cured tobacco varieties on green leaf yield

S/N	Sub plot treatments	Green weight yield (kg/ha)	Main plot treatments	Green weight yield (kg/ha)
1	S1 (1.15m*0.6m)	11765.50 c	V1 (KRK 26)	14168.75 ab
2	S2 (1.2m*0.5m)	13048.42 b	V2 (CC 26)	15159.18 a
3	S3 (1.2m*0.46m)	13785.74 b	V3 (CC35)	13016.88 ab
4	S4 (1.0m*0.5m)	15146.59 a	V4 (K 326)	11401.43 b
	Mean	13436.56		13436.56
	LSD	1190.30		2847.43
	CV (%)	12.35		12.35

NB: Means followed by different letters are significantly different by Duncan New Multiple Range p<0.05, Ns = Non-significant

Dry leaf weight yield and grade index

The highest dry leaf weight yield was obtained from spacing number four (table 4) which gave a yield of 2723.69 kg/ha, followed by spacing number three which gave a yield of 2564.89 kg/ha. The lowest dry weight yield was obtained from treatment number one which gave a yield of 2343.33 kg/ha. The results have also revealed that the dry leaf yield increased with the increase in plant population. There was no significance differences among treatments at $p<0.05$.

The highest dry leaf weight yield was obtained from variety number two (table 4) which gave a yield of 2887.39 kg/ha, followed by variety number one which gave a yield of 2557.74 kg/ha. The lowest dry leaf weight yield was obtained from variety number four which gave a yield of 2211.08 kg/ha. Treatment two differed significantly with treatments number three and four at $p<0.05$

Grade index

The highest grade index was obtained from spacing number two which was 1.76 followed by spacing number three which was 1.69. The lowest grade index was obtained from spacing number four which was 1.46. There was no significant differences among treatments at $p<0.05$

The highest grade index was obtained from variety number two which was 1.97 followed by variety number three which was 1.82. The lowest grade index was obtained from variety number four which was 1.55. There was no significant differences among treatments at $p<0.05$

Table 5: Effect of different spacing and flue cured tobacco varieties on dry weight yield and grade index

S/N	Sub plot treatments	Dry weight yield (kg/ha)	Grade index	Main plot treatments	Dry weight yield (kg/ha)	Grade index
1	S1 (1.15m*0.6m)	2343.33	1.57	V1 (KRK 26)	2557.74 ab	1.65
2	S2 (1.2m*0.5m)	2352.96	1.76	V2 (CC 26)	2887.39 a	1.97
3	S3 (1.2m*0.46m)	2564.89	1.69	V3 (CC35)	2328.66 b	1.82
4	S4 (1.0m*0.5m)	2723.69	1.46	V4 (K 326)	2211.08 b	1.55
	Mean	2496.22	1.62		2496.22	1.74
	LSD	455.78 Ns	0.373 Ns		508.21	0.397 Ns
	CV (%)	25.46	48.18		25.46	48.18

NB: Means followed by different letters are significantly different by Duncan New Multiple Range p<0.05, Ns = Non-significant

CONCLUSION AND RECOMMENDATIONS

In flue-cured tobacco (Nicotiana tabacum L.) production the aim is improvement of yield and quality (usability) of cured leaf. This has been achieved through development of new cultivars and adjustment of cultural practices. In Tanzania, most of the flue-cured tobacco is grown at plant spacing of 50 cm within and 120 cm between rows, i.e. at planting density of about 16,666 plants per ha. The results have shown that both green and dry leaf yield increased with the increase in plant densities, however they were non-significant. Moreover, the results have indicated that high leaf area and high dry leaf yield was obtained from variety number two (CC 26) which was 3901.48 cm2 and 2887.39 kg/ha respectively. The effect of spacing on leaf size, leaf area, dry leaf yield and grade index was non-significant at $p<0.05$. CC 26 was a better variety than others in terms of yield and quality. There was no interaction effects between spacing and variety.

Further work need to be done to investigate which spacing will be significant in terms of yield and quality in relation to flue cured tobacco varieties.

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Appendix 1: Indicative prices for 2014/15 crop season

S/n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Grade	X5L	L4O	L5O	XN1L	L5L	X3L	XN2O	X5O	C3L	L3L	X4O	XOV	X4L	L4L	C4L	P3L	N1O
Usd	0.950	2.080	1.675	0.730	1.630	1.590	0.510	1.015	1.860	2.440	1.420	0.700	1.370	2.00	1.447	1.505	1.00
S/n	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Grade	LOV	LOG	N1L	LOK	LLK	N2L	XN2L	N2O	LLV	X2L	L5L	LLG	L3O	P5L	XLV	C2L	X1L
Usd	1.300	0.060	0.910	0.210	0.100	0.845	0.470	0.890	1.250	1.990	1.630	0.055	2.540	0.730	0.650	2.270	2.190
S/n	35	36	37	38													
Grade	C3O	L2O	X3O	XN1O													
Usd	1.910	2.810	1.690	0.740													