EVALUATION OF DIFFERENT NPK FERTILIZER FORMULATIONS AND APPLICATION RATES IN FLUE CURED TOBACCO

Introduction

Soils in tobacco growing areas of Tabora have low nutrients levels. To get high yield a farmer needs to apply large amount of fertilizer per hectare. There was a need to have a new fertilizer formulation and rate which will improve yield.

Tobacco production requires N, P and K nutrients in proportions which suit soils of areas concerned. Understanding NPK fertilizer formulation starts with understanding the functions of each nutrient element in the formulation plus the added nutrients or micronutrients depending on different soils need.

Nitrogen improves the quality of leaf vegetables and fodders. It is responsible for vigorous growth, leaf production, size enlargement and hastens crop maturity.

Phosphorus is the second macronutrient most used in tobacco fertilization to most tobacco growing areas. Phosphorus stimulates early root development, leaf size, flowering, grain yield and hastens maturity.

Potassium requirements of tobacco are relatively high. High potassium content in flue-cured tobacco is needed for good smoking quality. Soils vary in their supply of available potassium, depending upon the parent material, previous fertilization, and cropping history. Approximately 112 to 196 kg/ha of potash (K20) are adequate for most soil conditions. Potassium may be lost by leaching from the root zone in extreme leaching conditions.

Potassium plays an important role in the photosynthesis and food production processes within the plant, increasing resistance to lodging and increases disease resistant mechanism of the plant. Potassium is more closely connected with the quality of the crop**.**

The application of adequate amounts of the proper nutrients is necessary for profitable tobacco production. Either under- or over-fertilization may result in a crop of unsatisfactory quality and reduced value. Excessive use of fertilizer is an unnecessary production cost and may have adverse environmental impacts. Proper fertilization has become imperative in recent years as contract tobacco purchases place specific requirements on the quality of tobacco. Therefore, careful attention must be given to the physical and chemical characteristics of the soil in selecting the rate and grade of fertilizer to be applied.

Objectives

The general objective is to improve flue cured tobacco yield and quality.

The specific objective is to evaluate NPK fertilizer formulations and rates in flue cured tobacco production.

On Station

Materials and methods

The trial was carried out at Tumbi by Tobacco Research Institute of Tanzania (TORITA) to evaluate the three NPK fertilizers formulations and rates in flue cured tobacco. This trial was carried out on station for two seasons, 2009/10 and 2010/11. Treatments with good performance were taken to the farmers as the on farm trials.

Plot size was 18x 38.4 m. Plant spacing was 120 cm from ridge to ridge and 55 cm from plant to plant. The variety used was K326.

The experimental design used was Randomized Complete Block design (RCBD) replicated three times.

Treatments tested were nine as summarized in Table 1 below to show interpretation of each fertilizer formulation and rates.

Table 1: NPK fertilizer formulations (bags and nutrient element per ha)

Treat.	Fertilizer	g/plant	bags/ha	N	P2O5	P	K2O	K
1	10:18:24	23	8	38.3	69	30	92	76.4
2	10:18:24	30	10	50	90	38.7	120	99.6
3	10:18:24	38	13	63.3	114	49	151	126
4	12:20:20	23	8	46	76.7	33	76.7	63.6
5	12:20:20	30	10	60	100	43	100	83
6	12:20:20	38	13	76	127	54.5	127	105
7	10:24:20	23	8	38.3	92	40	77	63.6
8	10:24:20	30	10	50	120	52	100	83
9	10:24:20	38	13	63.3	152	65.4	127	105

Management of Plots

Transplanting was according the spacing. Basal fertilizer application was done in the first week after transplanting and the second fertilizer application was done after three weeks after transplanting. Weeding and reridging were done three times , sucker controlled using Yamaotea super 8 ml/liters of water and Topping was done on at tenth weed after transplanting. Tobacco harvesting started one week before topping and continued as tobacco leaves matured.

Data collected

- Green weight of tobacco leaves
- Dry weight of cured tobacco leaves
- Leaf market grades

Analysis involved:-

- Green weight of tobacco leaves
- Dry weight of cured tobacco leaves
- Grade indices

Results and Discusssion

Green leaf yield

The collected data were organized through Excel data base and analyzed through Costat. Results for green leaf are indicated in Table 2 and show that the highest green weight was obtained from treatment six (NPK 12: 20: 20) at the rate of 38g per plant giving a mean weight of 11,787.46 kg/ha. The lowest yield was from treatment seven (N: P: K 10:24:20) at the rate of 23g per plant giving a mean weight of 8,191.74 kg/ha. There was no significant difference between all treatments at $P < 0.05$.

Dry leaf yield

The results of analyzed dry leaves show that the highest yield came from the sixth treatment (N:P:K 12:20:20 at the rate of 38g /plant) which giving a mean weight of 2517.09 kg/ha. The lowest yield came from treatment seven (N: P: K 10:24:20, 23g/plant) giving a mean weight of 1126.09 kg/ha. There was significant difference between treatment six and the remaining treatments. The remaining treatments were not statistically significant at $P < 0.05$ among

themselves. Results on dry leaf yield indicated in Table2, revealed that high yield came from NPK fertilizers which had the highest rate of Nitrogen nutrient followed by considerable high rate of P and K. In this case treatment six had 76 kg N/ha, 127 kg P2O5 /ha (54.5 kg P/ha) while potassium was 127kgK2O /ha (105 kg K/ha).

Treatment nine had the highest phosphorus with the same rate of potassium with treatment six did not give the highest dry leaves yield, showing that nitrogen has more influence in yield in less fertile sandy soil when applied with the phosphorus and potassium.

Table 2: The effect of different formulation of NPK fertilizer on green leaf and dry cured leaf weight (kg/ha) in two seasons

Treat no.	Treatments (Fertilizers)	Cropping season 2009/2010		Cropping season 2010/2011	
		Green weight kg/ha	**Dry weight kg/ha**	**Green weight kg/ha**	**Dry weight kg/ha**
1	N:P:K 10:18:24 23g	9650.0 bc	1351.25 c	11,048.61 ab	2,235.6 b
2	N:P:K 10:18:24 30g	9425 bc	1795.0 abc	8,550.92 b	3,493.13 ab
3	N:P:K 10:18:24 38g	11397.5 abc	2161.25 a	10,221.87 ab	3,663.35 ab
4	N:P:K 12:20:20 23g	9000.0 c	1366.25 c	7500.00 b	3,012.50 ab
5	N:P:K 12:20:20 30g	12175.0 ab	1978.75 abc	10,979.16 ab	3,031.93 ab
6	N:P:K 12:20:20 38g	11925.0 abc	2326.25 a	10,190.79 ab	3,775.35 a
7	N:P:K 10:24:20 23g	10275 bc	1476.25 bc	11,081.64 ab	2,231.14 b
8	N:P:K 10:24:20 30g	11200 abc	1941.50 abc	10,410.30 ab	3,138.09 ab
9	N:P:K 10:24:20 38g	13540.0 a	2112.5 ab	12,655.58 a	3,440.26 ab
	Mean	10954.17	1834.33	10,293.21	10,293.21
	l.s.d	2746.95	595.53	1,373.87	1,373.87
	C.V %	17.22	22.29	14.45	14.45

Maens followed by different letters are significantly different by Duncan New Multiple range P<0.05
ns = Non Significant.

ON-FARM

Materials and methods

The trial was carried out at Mtanila and Mabama village in Tabora to evaluate the two NPK fertilizers formulations and rates in flue cured tobacco for crop season 2011/2012. Plot size was 18x 38.4 m. Plant spacing was 120 cm from ridge to ridge and 55 cm from plant to plant. The variety used was K326.

The experimental design used was Randomized Complete Block design (RCBD) replicated three times.

Treatments tested were:

i. NPK 10:18:24 (23, 30 and 38 g/plant).

ii. NPK 12:20:20 (23, 30 and 38 g/plant)

The six treatments are summarized in Table 1 above to show interpretation of each fertilizer formulation and rates.

Data collected

- Green weight of tobacco leaves
- Dry weight of cured tobacco leaves
- Leaf market grades

Analysis involved:-

- Green weight of tobacco leaves
- Dry weight of cured tobacco leaves
- Grade index

Results and Discusssion

Mtanila

results show that Mtanila (Table...) farm had acidic soil pH 5.4 with very low N while P,K,Ca and C.E.C were low. To grow healthy and profitable tobacco crop there requires sufficient nutrients supply to meet the crop nutrients requirement.

Table 3: The summarized Soil results for Mabama and Mtanila farms.

S/N	Measured item	Mabama Uyui	Mtanila Chunya
1	pH	5.6 - Acidic	5.4 - Acidic
2	N (%)	0.04 - Very low	0.04 - Very low
3	P (mg/kg)	12.27 - Medium	12.27 - Medium
4	K (mg/kg)	0.08 - low	0.08 - low
5	Ca (mg/kg)	1.15 - low	0.47 - low
6	C.E.C (me/100g)	6.8 - low	6.8 - low

Leaf size

Leaf length and Width

In this trial leaf length and width were measured and representative average leaf length and width were calculated.

Top leaves

The highest average value of leaf length for top leaves was of treatment three (NPK 10:18:24 38g) which was 60.79 cm (Table; 2) followed by treatment two (NPK 10:18:24 30g) which was 59.63 cm long. The shorted leaves in average came from treatment one (NPK 10:18:24 23g) which was 57.12 cm long. There was no significant difference between all treatments at $P < 0.05$.

The highest average value of leaf width for top leaves was from treatment three (NPK 10:18:24 38g) which was 34.5 cm (Table;1) followed by treatment five which was 22.64 cm. The lowest average came from treatment one which was 18.92 cm. There were significant differences between treatment three which was the widest and treatment one at $P< 0.05$.

Middle leaves

The highest average value of leaf length for middle leaves was of treatment four which was 57.43 cm (Table 2), followed by treatment three which was 57.37 cm long. The shorted leaves in average came from treatment one which was 53.39 cm long. There was no significant difference between all treatments at $P < 0.05$.

The highest average value of leaf width for middle leaves was of treatment three which was 23.37 cm (Table;2), followed by treatment five which was 23.3 cm. The lowest average came from treatment one which was 21.12 cm. There were no significant differences between all treatments at $P< 0.05$.

Bottom leaves

The highest average value of leaf length for bottom leaves was of treatment three which was 38.6 cm (Table;1), followed by treatment two which was 37.92 cm.The shorted leaves in average came from treatment four which was 35.18 cm. There were no significant differences between all treatments at $P < 0.05$.

Treatment three had the highest value of average leaf width which was 21.34 cm followed by treatment five which was 20.19. The smallest value was calculated from treatment one which was 18.88 cm. There were no significant differences between all treatments at $P < 0.05$.

Table 4: Average leaf length and width for six treatments at Mtanila Chunya

T/no	Treatment	Top leaf data (cm)		Middle leaf data (cm)		Bottom leaf data (cm)	
		Length	Width	Length	Width	Length	Width
1	NPK 10:18:24 23gm	57.12	18.92	53.39	21.12	35.41	18.88
2	NPK 10:18:24 30gm	57.46	20.15	53.91	23.3	37.92	20.19
3	NPK 10:18:24 38gm	60.79	23.19	57.37	23.37	38.6	21.34
4	NPK 12:20:20 23gm	59.63	21.85	57.43	22.89	35.18	19.58
5	NPK 12:20:20 30gm	59.05	22.65	56.18	23.3	35.7	20.19
6	NPK 12:20:20 38gm	57.81	20.91	54.25	22.49	35.96	19.29
	Mean	58.64	21.28	55.42	22.40	36.46	19.92
	L.s.d	6.62	2.43	8.26	2.69	5.89	3.49
	CV (%)	6.20	6.29	8.19	6.61	8.89	9.66

Green leaf yield

The collected data were organized through Excel data base and analyzed through Costat computer program. Results for green leaf are indicated in Table 2 and show that the highest green weight was obtained from treatment five (NPK 12: 20: 20) at the rate of 30g per plant giving a mean weight of 11,855 kg/ha. The lowest yield was from treatment one (N: P: K 10:18:24) at the rate of 23g per plant giving a mean weight of 9,542 kg/ha. There was no significant difference between all treatments at $P < 0.05$.

Table 5: The effect of different formulation of NPK fertilizer on green leaf and dry cured leaf weight at Mtanila Chunya

Treat no	Treatment name	Green weight (kg/ha)	Dry weight (kg/ha)	Grade index
1	NPK 10:18:24 23g	9542	1648	1.02 b
2	NPK 10:18:24 30g	10593	1675	1.18 b
3	NPK 10:18:24 38g	10705	1852	1.58 b
4	NPK 12:20:20 23g	10880	1848	1.29 b
5	NPK 12:20:20 30g	11855	1937	1.98 b
6	NPK 12:20:20 38g	11257	1875	2.29 a
	Mean	10805	1806	1.56
	L.s.d	1975.1	413.2	0.99
	CV (%)	10	12.6	33.12

Means followed by different letters are significantly different by Duncan New Multiple range $P<0.05$, ns = Non Significant.

Dry leaf yield

The results of analyzed dry leaves show that the highest yield came from the fifth treatment (N:P:K 12:20:20 at the rate of 30g /plant) which gave a mean weight of 1937 kg/ha. The lowest yield came from treatment one (N: P: K 10:18:24, 23g/plant) giving a mean weight of 1648 kg/ha. There was no significant difference between all treatments at $P < 0.05$. Results on dry leaf yield indicated in Table2, revealed that high yield came from NPK fertilizers which had the highest rate of Nitrogen nutrient followed by considerable high rate of P and K.

Grade index

The average highest grade index was obtained from treatment six (2.29) followed by treatment five (1.98). The average lowest grade index was obtained from treatment one (1.02). There was significant difference between treatment one and six at $P<0.05$

Mabama

Leaf size

Leaf length and Width

In this trial leaf length and width were measured and representative average leaf length and width were calculated.

Top leaves

The highest average value of leaf length for top leaves was of treatment three (NPK 10:18:24 38g) which was 74.09 cm (Table; 3) followed by treatment six (NPK 12:20:20 38g) which was 73.09 cm long. The shorted leaves in average came from treatment one (NPK 10:18:24 23g) which was 63.52 cm long. Treatment one differed significantly with treatments 2, 3, 5 and 6.

The highest average value of leaf width for top leaves was from treatment six (NPK 12:20:20 38g) which was 35.39 cm (Table;1) followed by treatment five which was 34.46 cm. The lowest average came from treatment one which was 29.29 cm. Treatment one differed significantly with treatments 5 and 6 at $P< 0.05$.

Table 6: The average leaf length and width for six treatments

T/n	Treat	Top leaf (cm)		Middle leaf (cm)		Bottom leaf (cm)	
		Length	Width	Length	Width	Length	Width
1	NPK 10:18:24 23g	63.52	29.29	67.48	31.66	40.8	22.87
2	NPK 10:18:24 30g	71.22	31.77	67.73	31.1	44.2	24.6
3	NPK 10:18:24 38g	74.09	33.04	73.72	34.8	49.53	28
4	NPK 12:20:20 23g	67.81	31.59	65.87	30.42	41.8	40.96
5	NPK 12:20:20 30g	71.15	34.46	68.41	32.57	38.9	20.7
6	NPK 12:20:20 38g	73.09	35.39	68.15	32.92	40.51	23.03
	Mean	70.15	32.59	68.56	32.25	42.62	26.69
	L.s.d	6.98	4.41	10.38	5.19	7.52	24.83
	CV (%)	5.47	7.44	8.32	8.84	9.71	51.13

Middle leaves

The highest average value of leaf length for middle leaves was of treatment three which was 73.72 cm (Table 2), followed by treatment five which was 68.41 cm long. The shorted leaves in average came from treatment one which was 67.48 cm long. There was no significant difference between all treatments at $P < 0.05$.

The highest average value of leaf width for middle leaves was of treatment three which was 34.8 cm (Table;2), followed by treatment six which was 32.92 cm. The lowest average came from

treatment four which was 30.42 cm. There were no significant differences between all treatments at P< 0.05.

Bottom leaves

The highest average value of leaf length for bottom leaves was of treatment three which was 49.53 cm (Table;1), followed by treatment two which was 44.2 cm. The shorted leaves in average came from treatment five which was 38.9 cm. Treatment 3 differed significantly with treatments 1, 5 and 6 at P < 0.05.

Treatment four had the highest value of average leaf width which was 40.96 cm followed by treatment three which was 28 cm. The smallest value was calculated from treatment five which was 20.7 cm. There were no significant differences between all treatments at P < 0.05.

Green leaf yield

Results for green leaf are indicated in Table 3 and show that the highest green weight was obtained from treatment three NPK 10: 18: 24 (38g per plant) giving a mean weight of 18,180 kg/ha. The lowest yield was from treatment one (N: P: K 10:18:24) at the rate of 23g per plant giving a mean weight of 1420 kg/ha. There was no significant difference between all treatments at P < 0.05.

Dry leaf yield

The results of analyzed dry leaves show that the highest yield came from treatment N:P:K 12:20:20 at the rate of 38g /plant) which gave a mean weight of 3872.43 kg/ha. The lowest yield came from treatment one, N: P: K 10:18:24, 23g/plant giving a mean weight of 1712.69 kg/ha. There was significant difference between treatment 6 and all remaining treatments at P < 0.05

Table 7: The effect of different formulation of NPK fertilizer on green leaf and dry cured leaf weight (kg/ha).

Treat no	Treatment name	Green weight (kg/ha)	Dry weight (kg/ha)	Grade index
1	NPK 10:18:24 23g	16687.7	1712.69 b	2.02
2	NPK 10:18:24 30g	17843.5	2226.20 b	1.21
3	NPK 10:18:24 38g	19883.6	2080.96 b	1.52

4	NPK 12:20:20 23g	20319.0	2430.79 b	1.28
5	NPK 12:20:20 30g	22510.8	2593.93 b	1.03
6	NPK 12:20:20 38g	22056.6	3872.43 a	1.26
	Mean	19883.53	2486.17	1.39
	L.s.d	16277.89 ns	968.89	0.95 ns
	CV (%)	45.0	21.42	37.52

Means followed by different letters are significantly different by Duncan New Multiple range $P<0.05$,ns = Non Significant.

Grade index

The average highest grade index was obtained from treatment one (2.02) followed by treatment three (1.52). The average lowest grade index was obtained from treatment five (1.03). There was significant difference between treatment one and five at $P<0.05$

CONCLUSION AND RECOMMENDATIONS

Results from the on station experiment show that nitrogen contributed significantly to the leaf area. Large leaf area provides large surface area for solar radiation interception for photosynthesis. Potassium is the macronutrient which has the important role in photosynthesis and food production in leaves because the higher the photosynthesis the higher the biomass mass build up by the plant parts including leaves incase of tobacco plant.

Potassium greatly influenced leaf quality.

High phosphorus rates are important as the initial stage but if prolonged used after several years there might be a problem of high phosphorus build up in the soils.

The best performance was from treatment six, NPK, 12:20:20; with the rate of 38g/plant (76 kg N/ha, P_2O_5 127 kg/ha and K_2O 127 kg/ha. Increase in N influenced the increase in yield in both formulations as was observed at Mtanila Chunya (Table 5). Soils have low levels of N and K (Table 3). Apart from biomass increase, grade indices increased with increased fertilizer rates for both formulations. The higher the grade indices the higher is the leaf quality. Increased fertilizer rates with K improved leaf quality. Lower grade indices were observed in lower rates fertilizers because of insufficient N and K which are directly responsible for leaf quality.

Results from Mabama Uyui district research trial showed the best yield came from T6 with 60 Nkg/ha. The best performance by T4 was possibly influenced by P2O5 100 kg/ha and K2O 100 kg/ha. Increase in fertilizer rates increased biomass increase and eventually high leaf yield. It

revealed that the was low levels of N and K in the soil (Table 3), plants utilized the nutrients improved yield with increased rate of the fertilizers.

Mabama Uyui trial had a different trend grade index if compared to Mtanila Chunya results. The grade indices decreased with the increase in N rate. High N rates increase leaf biomass which requires special skill and experience to cure. As nitrogen rates were increased also grade indices decreased (Table..) implying that The farmer did not manage to cure properly heavy tobacco with high N contents.

Soils in tobacco growing areas of Tabora region are poor with low nutrients levels especially N which is responsible for plant growth and development and K(Table…and Table…) which is responsible for diseases resistance and leaf quality.

In order to improve tobacco yield and quality we need to use new NPK 12:20:20; with the rate of 38g/plant 76 kg N/ha, P_2O_5 127 kg/ha and K_2O 127 kg/ha

Treatment six, NPK, 12:20:20; with the rate of 38g/plant (76 kg N/ha, P_2O_5 127 kg/ha and K_2O 127 kg/ha had the potential to increase tobacco yield and quality and could be part of a solution to low nutrients level soils of tobacco growing area of Tabora and other parts of the country with poor sandy soils.

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