The Effects of Blended $N_{10}P_{18}K_{24}$ Fertilizer on Agronomic Performance Tobacco (*Nicotiana tabaccum* L) Plant and Quality of Flue Cured Tobacco Leaf

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Abstract

A study was conducted in sandy soil to evaluate the performance of blended $N_{10}P_{18}K_{24}$ followed by CAN 27%N fertilizer on tobacco yield and quality. The experiment was laid in a randomized complete block design (RCBD) during the 2021-22 cropping season at Tumbi, Tabora. The treatments had plot size of 2.5 m by 3.6 m and were unfertilized plot (T1), fertilized with blended YARA $N_{10}P_{18}K_{24}$ at 7 days after transplanting (DAT) followed by CAN 27% at 21 DAT tobacco seedlings (T2), fertilized with standard YARA $N_{10}P_{18}K_{24}$ at 7 DAT seedlings, followed by CAN 27% on the 21 DAT tobacco seedlings (T4) and fertilized with blended YARA $N_{10}P_{18}K_{24}$ at 21 DAT tobacco seedlings, followed by CAN 27% on the 35 DAT tobacco seedlings (T3). The four treatments were replicated three times. The results showed that application of basal blended NPK fertilizer at 21 DAT and top dressed with CAN 27%N at 35 DAT was superior and yielded higher leaf dry weight 2144.18 ± 77.16 kg/ha than application of basal blended NPK fertilizer at 7 DAT followed by top dressing at 21 DAT which had 1665.07 ± 217.17 kg/ha. Both blended treatments yielded more leaf dry weight than the treatment applied with basal standard compound NPK at 7 DAT followed by top dressing fertilizer CAN 27%N at 21 DAT (1501.94 ± 144.11 kg/ha). Nevertheless, the treatments applied with basal NPK and topdressing CAN 27%N at 7 and 21 DAT respectively, did not differ significantly with the tobacco dry leaf yield. Therefore, the current study recommends the application of the blended $N_{10}P_{18}K_{24}$ basal fertilization at 21 DAT, followed by CAN 27% top-dressing fertilizer at 35 DAT as it yielded significantly ($P \leq 0.001$) dry leaf of 2144.18 ± 77.16 kg/ha.

Keywords: nicotine; reducing sugar; blended NPK; YARA

Introduction

The Tanzania tobacco sector uses imported compound $N_{10}P_{18}K_{24}$ inclusion with 7% S, 0.012% B and 3% CaO for basal application at 30 g per plant seven (7) days after transplanting tobacco seedlings in the field of 16,666 plant population. This follows application of CAN 27% N with 1.7% MgO, 3% CaO and 3% S for top-dressing at twenty-one days after transplanting tobacco seedlings in the field at 8 g per plant. These fertilizers are of high quality and are desired for improving tobacco quality tobacco (Kidane *et al.,* 2013). The imported compound $N_{10}P_{18}K_{24}$ bag fertilizer cost higher by 22.5% than a bag of CAN 27% N fertilizer (TTC, 2021a). The $N_{10}P_{18}K_{24}$ fertilizer is linked to high-quality yield, which is contributed significantly by the N nutrient (Marchetti *et al.,* 2006; Waynick *et al.,* 2007; de Marchi Soares *et al.,* 2020).

The COVID-19 pandemic affected the Tanzania tobacco sector, which experienced an increase in imported tobacco fertilizer costs over the past three years. Other countries also experienced increased cost of agricultural inputs (Munthali and Xuelian, 2020; Höhler and Lansink, 2021; Shonhe, 2021). The impact of the COVID-19 pandemic resulted in emerging policy responses for adaptation and resilience-building for African countries (Willy *et al.,* 2020). During the 2021-22 cropping season, there was a shortage of tobacco compound $N_{10}P_{18}K_{24}$ fertilizer in Tanzania due to the lock-down (COVID-19 pandemic) that affected fertilizer production in Europe. Therefore, tobacco stakeholders agreed to be supplied with a YARA blended $N_{10}P_{18}K_{24}$ as it is cheap and had demonstrated good performance elsewhere (TTC, 2021b). Nevertheless, the price for a blended $N_{10}P_{18}K_{24}$ bag was also high, reaching \$ 44.50 in the 2021-22 crop season compared with \$ 34.5 in the 2020-21 crop season.

At Tobacco Research Institute of Tanzania (TORITA) YARA blended $N_{10}P_{18}K_{24}$fertilizer was evaluated by comparing the tobacco crop yields and quality with the yield due to standard compound $N_{10}P_{18}K_{24}$ fertilizer application. The $N_{10}P_{18}K_{24}$ compound fertilizer contains three component nutrients: nitrogen, phosphorus, and potassium, while the blended $N_{10}P_{18}K_{24}$ is blended mechanically to supply balanced nutrients to the soil. Research by Bozhinova (2019a) observed that the application of compound $N_{10}P_{18}K_{24}$ fertilizers significantly increased the leaf dry yield and quality of tobacco. In addition, the compound $N_{10}P_{18}K_{24}$ fertilizers have also been observed to increase the leaf P concentration significantly and improve the nicotine but reducing sugars (Bozhinova, 2019b). Furthermore, the compound $N_{10}P_{18}K_{24}$ releases the nutrients adequately in soils as it has excellent water retention ability, which effectively improves the utilization of fertilizer and water resources to the plants (Liang *et al.,* 2007).

The $N_{10}P_{18}K_{24}$ blended fertilizer application in soil showed great ability to reduce the soil acidity (Wamalwa, 2017) and give farmers good economic returns (Sitienei et al., 2018). The polyhalite blended $N_{10}P_{18}K_{24}$ fertilizer in flue-cured tobacco also resulted in higher leaf yield and quality of tobacco, similar to the compound $N_{10}P_{18}K_{24}$ fertilizers (Lisuma *et al.,* 2017). The YARA $N_{10}P_{18}K_{24}$ blended fertilizer has not been tested on its quality to the flue-cured tobacco crop in Tanzania. The prospects for the use of blended $N_{10}P_{18}K_{24}$ fertilizer in Tanzania's tobacco sector are promising and affordable. Import costs for the conventional fertilizer could be worsened by the recent Russian invasion into Ukraine and the associated sanctions imposed on Russia (Al-Maidi *et al.,* 2019; Georgievskiy and Bugina, 2020).

The main objective of the present study was to investigate the agronomic performance of YARA blended $N_{10}P_{18}K_{24}$ fertilizer for comparison with YARA compound $N_{10}P_{18}K_{24}$fertilizer on tobacco crop yields and quality by including a prolonged time for NPK blending fertilizer application. The findings will support the tobacco stakeholders to make informed decisions on the adoption and use of the fertilizer.

Materials and methods

Site description and experimentations

The field experiment was conducted in Tumbi, Tabora, Tanzania located at 05° 03′ 44.4″ S and 032° 40′ 07.4″ E, during the 2021-22 cropping season in sandy soil. The elevation of Tumbi, Tabora is 1151 m.a.s.l and the average annual rainfall, and temperature are 950 mm and 27 °C, respectively. The field experiment used the flue-cured tobacco variety K326 sourced from the Tobacco Research Institute of Tanzania (TORITA). Tobacco seed was sown in two seedbeds on 10th September 2021. One of the seedbeds with a size of 1.5 x 20 m was fertilized with 5 kg of standard YARA compound $N_{10}P_{18}K_{24}$ and the second seedbed with blended YARA $N_{10}P_{18}K_{24}$. The tobacco seedlings were hardened off two weeks before transplanting in the experimental field.

Matured tobacco seedlings were raised in seedbeds for about two months and transplanted in a Complete Randomized Block Design (CRBD). The four (4) treatments were replicated three times to the plot size of 2.5 m by 3.6m. The first treatment (T1) was the unfertilized plot. The second treatment (T2) was fertilized with blended YARA $N_{10}P_{18}K_{24}$ at a rate of 30 g per plant at 7 DAT seedlings, followed by top-dressing standard CAN 27% at the rate of 8 g per seedling on the 21 DAT tobacco seedlings. The third treatment (T3) was fertilized with blended YARA $N_{10}P_{18}K_{24}$ at a rate of 30 g per plant at 21 DAT tobacco seedlings, followed by top-dressing standard CAN 27% at the rate of 8 g per seedling on the 35 DAT tobacco seedlings. The prolonged blended fertilizer application period for T3 intended to determine its effective use following the full development of roots. The fourth (T4) treatment was fertilized with standard YARA $N_{10}P_{18}K_{24}$ at a rate of 30 g per plant at 7 DAT seedlings, followed by the top-dressing standard CAN 27% at the rate of 8 g per seedling on the 21 DAT tobacco seedlings. The experiment included a variation in application time for a blended fertilizer by applying basal NPK at 21 DAT and topdressing CAN at 35 DAT (T3) (Lisuma *et al.,* 2017; Lisuma *et al.,* 2023). Before applying blended $N_{10}P_{18}K_{24}$, they were thoroughly mixed to ensure all the particles were evenly spread per tobacco seedling. In addition, other agronomic management practices such as weeding, agrochemicals application, reaping tobacco leaves, curing of tobacco leaves, and grading were kept optimum.

Physical and chemical properties of the soils from experimental site

Six (6) soil samples were collected in different of the experimental site at a depth of 0–30 cm before experimentation. The sampled soils were mixed evenly to make a composite soil sample. The composite soil sample was air dried for about a week, then ground and sieved through a 2 mm sieve mesh size for laboratory analysis. The sieved soil samples were determined on organic carbon (OC) by the Walkley Black method as modified by Moberg (2000), while the soil pH was determined using a soil: water ratio of 1:2.5 extractant (Moberg, 2000). The total nitrogen (N) was determined by the Kjeldahl method (Moberg, 2000), while the available phosphorous (P) was determined by Bray-1 method. The exchangeable calcium (Ca), potassium (K), magnesium (Mg) and sulphur (S) was determined by Atomic Absorption Spectrophotometer, and boron (B) was determined by extractable water B as described by Moberg, (2000).

Data collection

A middle-matured leaf was sampled from three plants located at the middle ridge. The leaf samples were measured in length and width using tape. The leaf area was calculated based by multiplying leaf length and width with a correction factor of 0.6345 as given by Yang *et al.* (2019). Harvested tobacco leaf samples from each experimental plot were weighed and loaded into the oven to dry tobacco leaf to a constant weight at 65°C. The oven-dried leaf samples were chopped into small pieces, grounded in a grinder and sieved through a 0.5 mm woven wire to determine B, Ca, N, P and K using the dry ash and wet digestion method (Moberg, 2000). Reducing sugar was determined based on Fernández-Novales *et al.* (2009), while nicotine was determined by spectrophotometric analysis (Figueiredo *et al.,* 2009).

The tobacco leaves were harvested on the 9th, 10th, 11th, 12th, 13th and 14th week after seedlings transplanting to the plots. The harvested green leaves were weighed immediately after harvesting using a digital balance scale, then tied to a stick and loaded into the curing barns for each harvesting batch. Dried leaves were weighed on a digital scale. The grades were allocated by the Tanzania Tobacco Board (TTB) Classifier for each of the treatments, including the price per each grade as endorsed by the second extraordinary Tanzania Tobacco Council meeting (TTC, 2021c). The grade index was calculated based on the weight of the sold tobacco leaf multiplied by the price allocation and divided by the overall tobacco weight.

Statistical analyses

Data were analyzed using the Statistica 8.0 software package version 7. Green and dry leaf weight were evaluated based on the interactions among the treatments, fertilizer regime and each factor individually. The two-way ANOVA statistical analyses were performed through RCBD, with fertilizer treatments. Fisher's least significance comparison tests was used at p=0.05 and P=0.001 for high significance. The treatment means were compared by the standard error of the mean difference.

Results

Physical and Chemical Properties of the Experimental Soil

The textural class of the experimental soil was categorized as sand soil with 7.4% of clay, 0.92% of silt and 91.68% of sand. Other chemical properties of the experimental soil, are presented in Table 1. Based on Landon (1991), the soil pH 5.23 was rated as acidic, medium (1.85%) for organic carbon (OC), soil available P detected at 3.07 mg/kg was very low, soil total N was low (0.12%), Exchangeable soil potassium (K) was very low (0.05 cmol (+)/kg). The soil B was very low (0.04 mg/kg), S (75.23 mg/kg) was very high, and Mn (10.26 mg/kg) was medium. The exchangeable calcium (Ca) recorded at 1.31 and magnesium (Mg) at 0.28 cmol (+)/kg were low.

Table 1 Selected soil properties before the experiment

Soil pH	OC (%)	Total N (%)	P (mg/kg)	K Cmol (+)/kg	Ca Cmol (+)/kg	Mg Cmol (+)/kg	Mn (mg/kg)	S (mg/kg)	B (mg/kg)
5.23	1.85	0.12	3.07	0.05	1.31	0.28	10.26	75.23	0.04

Growth and yield responses of tobacco to different fertilizers application

Data on growth and yield responses of tobacco following the application of different fertilizers are shown in Table 2. The absolute control (T1) had the significantly (P≤0.001) lowest leaf area, 522.89 ± 44.80 cm², while the blended $N_{10}P_{18}K_{24}$ at 7 DAT and top-dressed with standard CAN 27% fertilizer after 21 DAT (T2) had the leaf area of 737.80 ± 44.12 cm², which did not differ significantly with the standard $N_{10}P_{18}K_{24}$ at 7 DAT top-dressed with standard CAN 27% fertilizer at 21 DAT (T4) which had 857.45 ± 22.49 cm². However, application of the blended $N_{10}P_{18}K_{24}$ at the 21 DAT followed by top-dressed at 35 DAT (T3) had a significantly (P≤0.001) highest leaf area (914.58 ± 35.78 cm²) than the rest of the treatments. For green leaf yields, the absolute control (T1) had significantly (P≤0.001) lowest green, but the rest of the treatments T2-T4 did not differ significantly. The lowest significant (P≤0.001) dry leaf yield of 854.04 ± 111.64 kg/ha was recorded in the absolute control (T1) in comparison to the standard treatment (T4), which had a dry leaf yield of 1501.94 ± 144.11 kg/ha. The T2, with the application of blended $N_{10}P_{18}K_{24}$ at 7 DAT followed by CAN at 21 DAT, had 1665.07 ± 217.17 kg/ha, which did not differ significantly (1501.94 ± 144.11 kg/ha) from the standard treatment (T4) applied with $N_{10}P_{18}K_{24}$ and CAN at 7 and 21 DAT, However, the treatment T3, blended $N_{10}P_{18}K_{24}$ applied at 21 DAT followed by top-dressing of CAN at 35 DAT, had the highest dry leaf yield (2144.18 ± 77.16 kg/ha) than the rest of the treatments.

Effects of Fertilizer Treatments on nutrient leaf concentrations

The effect of fertilizer application on nutrients leaf concentrations is shown in Table 3. The leaf B concentrations differed significantly (P≤0.001) across the treatments; the lowest B concentrations were recorded in unfertilized tobacco plants (T1). In the standard compound $N_{10}P_{18}K_{24}$ treatment applied on 7 DAT followed CAN 27% on 21 DAT (T4) had significantly

Table 2: Effect of different fertilizers on tobacco leaf area, green and dry leaf yields

Treatments	Leaf area (cm²)	Green leaf yield (kg/ha)	Dry leaf yield (kg/ha)
T1 - Absolute control	522.89 ± 44.80 c	17495.17 ± 1773.06 b	854.04 ± 111.64 b
T2 - Blended $N_{10}P_{18}K_{24}$ 7 DAT+CAN 21 DAT	737.80 ± 44.12 b	32420.80 ± 4324.52 a	1665.07 ± 217.17 ab
T3 - Blended $N_{10}P_{18}K_{24}$ 21 DAT+CAN 35 DAT	914.58 ± 35.78 a	36819.71 ± 2416.87 a	2144.18 ± 77.16 a
T4 - Standard $N_{10}P_{18}K_{24}$ 7 DAT+CAN 21 DAT	857.45 ± 22.49 ab	30593.72 ± 1952.63 a	1501.94 ± 144.11 b
F-statistics	20.92***	8.77**	13.16**

*Means in the same category of evaluated interface sharing similar letter(s) do not differ significantly based on their respective Standard error (SE) at 5% error rate. Values presented are means±SE $\bar{x}$ (Standard error of means); *, **, *** means significant at P<0.05, P<0.01, P<0.001*

(P≤0.001) highest leaf B concentrations 16.74 ± 0.02 mg/kg. A treatment T3 blended $N_{10}P_{18}K_{24}$ at 21 DAT followed CAN 27% at 35 DAT had a significant higher B leaf concentration of 16.65 ± 0.02 mg/kg than T2 (15.26 ± 0.02 mg/kg) with similar $N_{10}P_{18}K_{24}$ and CAN 27% applications, but at 7 and 21 DAT. Similar trends to B leaf concentrations were also observed for leaf N, which differed significantly across the treatment.

Table 3: Effect of fertilizer treatments on nutrient tobacco leaf concentrations produced from Tumbi, Tabora site

Treatments	Leaf B (mg/kg)	Leaf Ca (%)	Leaf N (%)	Leaf P (%)	Leaf K (%)
T1 - Absolute control (No fertilizer)	13.86 ± 0.02 d	0.23 ± 0.02 a	1.54 ± 0.02 d	0.17 ± 0.02 b	1.29 ± 0.02 b
T2 - Blended $N_{10}P_{18}K_{24}$ (Microp) 7 DAT + CAN 21 DAT	15.26 ± 0.02 c	0.25 ± 0.02 a	2.17 ± 0.02 c	1.06 ± 0.02 a	1.83 ± 0.02 a
T3 - Blended $N_{10}P_{18}K_{24}$ (Microp) 21 DAT + CAN 35 DAT	16.65 ± 0.02 b	0.27 ± 0.02 a	2.75 ± 0.02 a	0.88 ± 0.02 a	1.79 ± 0.02 a
T4 - Standard $N_{10}P_{18}K_{24}$ (Compound) 7 DAT + CAN 21 DAT	16.74 ± 0.02 a	0.26 ± 0.02 a	2.32 ± 0.02 b	0.21 ± 0.02 b	1.81 ± 0.02 a
F-statiscs	3464***	0.5469ns	470.81***	390.87***	127.25***

*Means in the same category of evaluated interface sharing similar letter(s) do not differ significantly based on their respective Standard error (SE) at 5% error rate. Values presented are means ±SE $\bar{x}$ (Standard error of means); *** means significant at P<0.001; ns=non-significant (P≥0.05)*

Leaf Ca concentrations did not differ across the treatment, while for leaf K, only the absolute control (T) had the significant (P≤0.001) lowest leaf K concentrations 1.29 ± 0.02% and for the rest treatments did not differ significantly. The lowest P leaf concentration was recorded in the standard (T4) treatment (0.21 ± 0.02%) and the absolute treatment (T1), which had 0.17 ± 0.02%. The blended treatments T2 applied with blended $N_{10}P_{18}K_{24}$ at 7 DAT at 30 g per plant followed by top-dressing using CAN 27% and treatment (T3) with the same application rates for $N_{10}P_{18}K_{24}$ and CAN 27% but at 21 and 35 DAT, respectively did not differ significantly.

Effects of Fertilizer Treatments on tobacco leaf reducing sugars, nicotine and grade index

The absolute control (T1), had a significantly (P≤0.001) higher reducing sugar by 22.32 ± 0.02% than all fertilized tobacco treatments, which did not differ significantly among them (Table 4). Leaf nicotine fertilized blended $N_{10}P_{18}K_{24}$ at 21 DAT and top-dressed with standard CAN27% (T3) had significantly leaf nicotine 2.56 ± 0.02% than the standard compound $N_{10}P_{18}K_{24}$ (T4) and blended $N_{10}P_{18}K_{24}$ (T2) applied followed by CAN 27% at 7 and 21 DAT, respectively, which did not differ among them. The standard treatment (T4) and the blended $N_{10}P_{18}K_{24}$ at 21 DAT, followed by CAN

Table 4: Effects of fertilizer treatments on tobacco leaf reducing sugar, nicotine content and grade index

Treatments	Reducing sugar (%)	Nicotine (%)	Grade Index
T1 - Absolute control (No fertilizer)	22.32 ± 0.02 a	1.27 ± 0.02 c	0.28 ± 0.02 c
T2 - Blended $N_{10}P_{18}K_{24}$ (Microp) 7 DAT + CAN 21 DAT	16.27 ± 0.02 b	2.48 ± 0.02 b	0.85 ± 0.02 b
T3 - Blended $N_{10}P_{18}K_{24}$ (Microp) 21 DAT + CAN 35 DAT	16.21 ± 0.02 b	2.56 ± 0.02 a	0.98 ± 0.02 a
T4 - Standard $N_{10}P_{18}K_{24}$ (Compound) 7 DAT+CAN 21 DAT	16.24 ± 0.02 b	2.45 ± 0.02 b	0.96 ± 0.02 a
F-statistics	17328***	709.38***	204.17***

*Means in the same category of evaluated interface sharing similar letter(s) do not differ significantly based on their respective Standard error (SE) at 5% error rate. Values presented are means ±SE $\bar{x}$ (Standard error of means); *** means significant at P<0.001; ns=non-significant (P≥0.05)*

27% at 35 DAT, had significantly grade indexes. Next to these treatments, T2 (blended $N_{10}P_{18}K_{24}$ at 7 DAT and CAN at 21 DAT) had a graded index of 0.85 ± 0.02%. In contrast, the absolute control (T1) had the lowest grade index, 0.28 ± 0.02%.

Discussion

Response of fertilizer applications to inherent low soil nutrients

The inherent low N, P, K, Ca and Mg (Table 1) influenced the good tobacco crop response following $N_{10}P_{18}K_{24}$ and CAN fertilizer applications. The $N_{10}P_{18}K_{24}$ fertilizer improved N, P and K levels in the soils. The application of $N_{10}P_{18}K_{24}$ at the early tobacco stage is most important for supplying P nutrients for developing roots (Lopez-Bucio *et al.,* 2000). Additional application of CAN fertilizer as the top-dressing fertilizer improved N and Ca levels in the soils and for tobacco plant nutrient uptake. Improvement of Ca and N in the soils could result in N influencing the growth and quality of flue-cured tobacco, while Ca has a strong influence on biomass and dry matter production (Lisuma *et al.,* 2020). The high levels of soil S could have influenced the uptake more of N by the tobacco plant and influenced more yields and quality of the treatments receiving fertilizers. The study by Clarkson *et al.* (1989) observed that S interact with N so that inadequacy of either N or S reduces the uptake and assimilation of the other. Therefore, other studies have observed the S requirements in crops to be increasingly recognized as the fourth nutrient after nitrogen, phosphorus and potassium (Herschbach and Rennenberg, 1994; Jamal *et al.,* 2010).

The significant ($P \leq 0.001$) low yield for the absolute control (T1), could be caused by the low inherent soil nutrients such as N, P, K and Ca. Thus, the leaf area in this treatment, 522.89 ± 44.80 cm^2, was the lowest of the treatments. The dry leaf yields (1665.07±217.17 kg/ha) of tobacco plots applied with the blended $N_{10}P_{18}K_{24}$ at 7 DAT followed by the CAN 27% top-dressed fertilizer after 21 DAT (T2) did not differ significantly with the (T4) standard $N_{10}P_{18}K_{24}$ at 7 DAT top-dressed with standard CAN 27% fertilizer at 21 DAT (1501.94±144.11 kg/ha) indicating that the performance of nutritive values of these fertilizers was the same.

Response of fertilizer application duration on leaf yield and nutrient concentrations

However, the current study observed that the application of blended $N_{10}P_{18}K_{24}$ at the 21 DAT followed by top-dressed at 35 DAT (T3) increased dry leaf yields significantly ($P \leq 0.001$). The study further revealed that a period of seven days determines the number of seedlings required for gap filling, which will also take another seven days to establish a good standing crop in the field. Therefore, applying $N_{10}P_{18}K_{24}$ basal fertilizer at 21 DAT is more economical in utilizing nutrients by plants as roots will have been well established. Thus, the increase of dry leaf yields as a result of a two-week extended period for fertilizer application could also reflect the proper utilization of nutrients uptake by the roots for dry matter formation and hence increased yields.

A study by Moustakas and Ntzanis (2005) observed almost similar results that higher tobacco dry matter accumulation and nutrient uptake were observed between 41 and 71 days after transplanting tobacco. Thus, during this period, the soil should have sufficient nutrients for tobacco plant needs, especially for N, P and K, which are observed to have a significant impact on yield and quality increase (Karaivazoglou *et al.,* 2007).

The leaf Ca concentration did not differ across the treatments, indicating that the tobacco plant has a mechanism of stimulating Ca levels in soils for its uptake to influence biomass and dry matter production. Another study also observed the increased Ca levels in the soil media after tobacco production, which released nicotine to the rhizosphere, increased the soil acidity, decomposed OC, and increased Ca in soils (Lisuma *et al.,* 2020). In terms of B supply to the tobacco plant, a standard compound $N_{10}P_{18}K_{24}$ fertilizer was the best as the leaf B concentration was significant ($P \leq 0.001$) higher than the rest treatment. However, applying the blended $N_{10}P_{18}K_{24}$ fertilizer at 21 DAT could benefit the tobacco leaf yields. During that period, tobacco plants had significantly higher massive developed roots to absorb efficiently nutrients such as Ca, N, P and K. Furthermore, the tobacco plants also had significant ($P \leq 0.001$) higher nicotine and grade index, which did not differ from the tobacco plants fertilized with the standard compound $N_{10}P_{18}K_{24}$ fertilizer. Another study also observed that nutrients Ca, N, P and K influenced considerably higher tobacco yields (Karaivazoglou *et al.,* 2007). Therefore, our study showed that the application of blended $N_{10}P_{18}K_{24}$ and standard compound $N_{10}P_{18}K_{24}$ did not differ significantly in dry leaf yields.

Conclusion

The basal application of blended $N_{10}P_{18}K_{24}$ fertilizer at 7 DAT and top-dressing fertilizer with standard CAN 27% at 21 DAT produced 1665.07±217.17 kg/ha dry tobacco leaf yields which did not differ significantly with 1501.94±144.11 kg/ha dry tobacco leaf yields fertilized with standard compound $N_{10}P_{18}K_{24}$ at 7 DAT and top-dressed with standard CAN 27% at 21 DAT. However, the current study recommends the application of the blended $N_{10}P_{18}K_{24}$ at 21 DAT followed by the standard CAN 27% top-dressed fertilizer after 35 DAT as the dry leaf yields increased significantly (2144.18 ± 77.16 kg/ha) with good quality tobacco than the current basal $N_{10}P_{18}K_{24}$ application at 7 DAT followed by top-dressing CAN fertilizer at 21 DAT.

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Conflicts of Interest

The authors declare to have no conflict of interest regarding this paper's publication.

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