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Effect of Nitrogen Rate and Intra-Row Spacing on Yield Components and Quality of Tobacco (*Nicotiana tabacum L.*) under Irrigation Condition at Achura in Wolaita Zone, Southern Ethiopia

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ABSTRACT

Tobacco is an important cash crop and it is source of income for small holder farmers and commercial farms in Ethiopia. However, its production is constrained mainly by a number of factors of which low Nitrogen nutrient and un-optimum intra-row spacing are major factors. Thus, a field experiment was conducted at Boloso Sore woreda in Wolaita Zone during 2016 cropping season under irrigation condition to study the effect of different levels of N rate and intra-row spacing on yield, yield components and quality of tobacco. The experiment was laid out in factorial arrangement comprising four nitrogen rates (0, 40, 60 and 80kg N/ha) and four intra-row spacing (40, 45, 50 and 55cm) in Randomized Complete Block design replicated three times. The crop parameters such as leaf area, number of leaves, plant height, fresh leaf yield, dry leaf yield, nicotine content, nitrogen content and sugar content on the leaf of tobacco plant were collected and analyzed. The results showed that, the highest green leaf yield 25636.4 kg/ha, dry leaf yield 3662.34kg/ha and total biomass of 57662.9kg/ ha were recorded from plants grown on plots receiving 80kgN/ha and with intra row spacing 50cm. The least value of above mentioned parameters were obtained from plots grown on plots receiving nil N application with 45cm intra-row spacing. Furthermore, partial budget analysis revealed that the highest net return (96602.86 Eth.Birr) was obtained from plants grown on plots supplied with 80 kg N/ha along with 50cm intra-row spacing. Thus, it could be concluded that combined application of 80kg N and 50cm intra-row spacing was boosted tobacco yield and economically feasible for the study area

Keywords: *growth parameters, interaction effect, intra row spacing, and yield components*

INTRODUCTION

Tobacco *(Nicotiana tabacum* L.*)* is an herbaceous annual or perennial plant in the family Solanaceae grown for its leaves. The archaeological record regarding the origin and diffusion of cultivated tobacco in the America suggests that the plant emerged in west-central South America, and was brought to north from both east and west to Central America. From there, it moved up to south-western United States, and continued to move north across the Great Plains. Access to the east was largely via the Plains (Winter, 2000).

It is rather new crop plant as compared to other staples and its initiation is coincident with discovery of America continent (Sabeti, 2004). Since the 1960s, the bulk of production has moved from the America to Africa and Asia. Around the world, cultivated tobacco occupies about 3.9 million hectare of which 60% is 'flue-cured' tobacco, 13% is burley tobacco, and 12% is oriental (Rojo, 2008).

Leaf of tobacco is traded in the world market for three main reasons. Firstly, some countries do not produce tobacco, produce too little or not produce a particular kind of tobacco. Secondly, some countries do not produce high enough quality tobacco or enough of it to meet domestic demand; and thirdly, prices vary for given kinds and qualities between countries with different product demand mixes (Grise, 1990). It is one of the most profitable crops in many countries. Each year, five trillion cigarettes are manufactured. According to Food and Agricultural Organizations (FAO) report in 2003, China, Brazil, India and United States are among the top ten leading countries to grow tobacco.

The national tobacco enterprise (Ethiopia) Share Company has been operational in the country for more than 50 years. It has been producing tobacco around Shewa Robit, Bilate, Hawassa and Wolaita to supply its leaf processing plants and furnishes the cigarette making factory in Addis Ababa. The total production in Ethiopia is about 2760 ton of dry leaf which 1500 ton at Show-Robi, 600 ton at Bilate, 320 ton of Hawassa and 340 ton at Wolaita. In Ethiopia, the productivity is not more than 2000kg/ha dry leaf, but in developed world there were about 4000kg/ha dry leaf. Nevertheless, the domestic productions have never full filled the demand of the factory for processed tobacco leaves. This is because the production and productivity of tobacco has never been improved (Daniel, 2015).

Tobacco grows very well in a wide range of climates and the optimum temperatures ranging from 20-30^{0}c (68-86^{0}F) in areas where there is dry period to facilitate harvest of the leaves. It can grows on variety of soils. The type of soil depends on the variety being cultivated. It also grows well in sandy soil with low water holding capacity. However, the best yield is usually obtained in loam to sandy loam soils and it is also tolerant to extreme weather conditions (Jacoba *et al*, 2000).

Nitrogen is one of the basic growth elements and direct impacts on tobacco growth and development (Rostami, 1995). Nitrogen nutrition has a profound effect on development and biochemical properties of flue cured tobacco (Miner, 1983). This is due to the relationship of N and vegetative growth. It is the element that has the highest effect on the growth and quality of 'flue-cured' tobacco (Parker, 2009).

Thus a large quantity of N fertilizer is used in the cultivation of flue cured tobacco in the developed world (Mc Cants, 1967). It determines the performance of leaf blade, the qualities and taste of aroma, and the smoke taste (Smith, 2009). Excessive or improper applications' of N may affect the yield and quality of 'flue-cured' tobacco (Reed *et al.*, 2011). Excess N produces strong and spicy flavors, which are not associated with high nicotine contents.

For the cultivation of tobacco, the recommendations for nitrogen vary according to soil types, 67 and 78 kg/ ha (Reed *et al.*, 2011). Besides, the cultural operation recommended for successful production of different types of tobacco depends on available resource and its managements. Among growing practices, plant spacing can affect agronomic and chemical traits of tobacco (Collins and Hawks, 1993). The operation of pulling seedlings and planting in the field is common to all tobacco including flue-cured tobacco. Planting distances, however, have much influence on the type of leaf to be produced. Spacing between plants in the field varies according to the type of tobacco and where it is grown and the chemical composition in leaf production is a function of plant and leaf population. Different type of tobacco has various size leaves and grows to various heights. If they are planted too close together some of the leaves may not receive enough sunlight. Wider spacing will produce more leaves per-plant, which will be large and including a higher proportion of medium to heavily bodied tobacco. Conversely, closer spacing decreases the proportion of the low priced tip grades and increases the amount of thin bright tobacco and open-grained upper leaves and has lower nicotine content. It has been shown that distance between plants in the row had more influence on yield and quality than those between rows (Boyce, 1965**)**.

However, field observation in Wolaita area, shows that the field practices are very far from the recommendation i.e. either very higher or very low density are being practiced in tobacco plant. Besides, tobacco leaf production at Achura area in Wolaita Zone is highly constrained by low soil fertility, especially N deficiency and intra-row spacing. Consequently, lacks of recommended N fertilizer rate and plant density are the major problems of area on tobacco leaf production. Therefore, the objectives of this study were: To evaluate the growth, yield, quality and economic response of tobacco in response to N and intra-row spacing and to determine N rate and intra-row spacing for tobacco production in the study area.

MATERIALS AND METHODS

Description of the Experimental Site

The field experiment was conducted at Achura kebele in Boloso Sore woreda in Wolaita Zone, South Nations Nationalities and People Region, during the Belg season of 2017 under irrigation condition. The area is 300 kilometers southwest of the Addis Ababa. Geographically, it is located in 37º 42´ 00" E longitude and 7º 04' 0.01" N latitude and at an average elevation of 1785 meter above sea level and having an average annual rain fall of 1750mm. The mean monthly temperature of the area is 20.4^{o}c. The experimental area is classified as moisture stress area having nearly no rain in Belg season (BSWAO, 2016). The experimental site soil was taken to Regional soil laboratory and analysis taken for physico-chemical properties of the experimental site.

As a result, it is clay in texture. The soil P^H was 6, rated as moderately acidic soil. Organic carbon content was 2%, rated as low. Total nitrogen content was 0.05%, categorized under low level (Landon, 1991). The available P content was 1.84 mg P_2O_5 kg^{-1}, rated under very low content (Cottenie, 1980). The cat-ion exchange capacity content was 33.24cmol (+) kg $^{-1}$, rated under medium category (Landon, 1991).

Treatment and Experimental Design

The treatments were consisted of four rates of nitrogen fertilizer (0, 40, 60 and 80 kg/ha) and four intra row spacing (40, 45, 50 and 55cm). The treatments were combined in factorial arrangement and laid out in randomized complete block design with three replications. The block was separated by 1.5m wide space and each plot was separated by 1.5m space. Each treatment was randomly assigned to experimental unit within a block.

Material Used and Agronomic Practices

A tobacco cultivar PVH-2299, which was male sterile and newly introduced from Brazil was used as a test crop. The cultivar is high yielder and with better quality as compared to other cultivars. It set flowers after first or second harvesting and grows to a height of 2-3m height. The cultivar can give the up to 3000kg/ha dry leaf yield at normal condition (Mekonnen, 2014). Urea was used as sources of N-fertilizer, where, the first half was applied at transplanting and the remaining half was applied near knee height of the plant.

Experimental field was ploughed twice by using a tractor and then, pulverized and leveled to get smooth plot. Before field practice healthy seedling raised at Boditi farm and transported to experimental site for transplanting. Gap filling practice was done to substitute died seedlings to maintained to proposed plant density per plot. Irrigation water was provided to seedlings by observing the water weekly by using surface irrigation. All other crop management practices such as cultivation, weeding, diseases and insect control were carried out as desired during crop growing season.

Data Collection and Measurement

Crop Data

Phenological Parameters

Days to First Leaf Emergence

After transplanting the seedling, emergence of leaf was taken by visual observation after two weeks. After 10-12 days of transplanting there were more than 75% every plot, the first leaf was emerged. **Days to flowering:** was counted as number of days from planting to when 75% of the plants in each net plot produced flower.

Growth Parameters

Leaf Number per Plant (No)

It was recorded from the four selected middle plants by counting all leaves starting priming up to tips from each treatment. **Leaf number per plot (No.):** It was taken by taking all plants from each treatments of a plot and counting all leaves found in a plant after flowering. **Plant height (m):** It was measured from middle rows excluding the border plants. The plant height was measured from the base of the plant to the tip of the main shoot after flowering. Then four plants were taken from each treatments and each replication at the middle part of the plot. **Leaf area per plant (cm^{-2})**: It was measured by taking four plants from the middle rows after initiation of flowering by using ruler/meters and calculated by using methods of Mykee (1964). Leaf area (LA) =Length x Maximum width of leaf x 0.733.

Yield

Green Leaf Yield per Plant (kg/plant)

The total mass of the leaf per plant was measured during successive harvesting. Those plants were selected every plots of the treatments and the average was taken. After measuring green leaf yield it was converted to dry leaf yield by using the ratio of seven to one or 7:1 (Abinat, 2013). **Green Leaf Yield per hectare (kg/ha):** Total mass of the leaf was measured from each plot of the treatments and the average mass was converted to per hectare after completing of harvesting of all leaves by successive harvesting. **Dry leaf yield per hectare (kg/ha):** Total mass of the leaf was measured from each plot of the treatments and dried in burn house, and then the average mass was recorded up to completing of harvesting of all leaves by successive harvesting. **Total above ground biomass (kg/ha):** The total leaf yield plus above ground stock of the tobacco per hectare was recorded.

Leaf Quality

For leaf quality analysis the leaf sample from each treatment was taken during each harvesting and dried in burn house. Then after, the dried leaf where transported to National Tobacco Enterprise laboratory at Addis Ababa, Ethiopia. Dried leaves of tobacco samples were grounded and sieved within about 2 mm mesh and oven dried at 60^{o}c for 24 hr to a constant weight about 0.5 gm lots weighed and extracted with 10 ml at 25 ml phosphate buffered ($P^H{}_=7.8$) in water bath adjusted at 30^{o}c for 24 hr with constant agitation. The aqueous extract was filtered through filter paper and the filtrate was stored in refrigerator for these purposes four leaf positions were collected. Then, nicotine, sugar and N of tobacco leaf were determined by the methods described by of Sounders and Blume (1981).

Partial Budget Analysis

Economic analysis was performed following the evaluation, cost and return, and benefit was calculated accordingly to the procedure described by CIMMYT (1998). The variable cost includes cost of fertilizer. Benefit cost ratio was calculated as the ratio of net return to the total cost. To estimate economic parameters, green tobacco leaf yield was evaluated at an average open market price per kg, workdays per hectare for collection and cost of chemical fertilizers was considered.

Statistical Analysis

The data were subjected to analysis of variance (ANOVA) using SAS version 9.2 computer software (SAS, 2009). Mean difference for significant difference was separated following least significant difference (LSD) procedures at 5% level of probability.

RESULTS AND DISCUSSION

Plant Height (m)

Analysis of variance revealed that N-rates by intra-spacing interaction resulted in significant differences on plant height (table 1). Generally, plant height tended to increase with intra-row spacing as N-rates increased. The tallest plant height (2.35m) was recorded at N-rate of 80kg/ha with intra-row spacing of 40cm followed by the same N-rate with plant spacing of 45cm with mean plant height of 2.16m.

The shortest plant height (0.83 m) was recorded from nil N application plots with intra-row spacing of 40cm. It is noted that a successive increase of N fertilizer with minimizing intra-row was attributed to the gradual increase in plant height. The reason for increase in plant height with increasing amount of N fertilizer and decreasing intra row spacing could be attributed to the effect of N on vegetative growth, cell division in plant organs; especially stems and provides suitable conditions for stem elongation. Further, this might be due to high competition for light radiation in because of intra competition on closer spaced plants than on wider spaced plants.

Similarly, Ahmed and Abdall (2006) reported that N application had increased plant height and yield. In conformity with this result, Bukan (2008) pointed out that tobacco crop plants grown at closer intra row spacing will suffer severe resource competition to greater extents and they tend to produce taller stalks due to negative response to light and nutrient competition.

Table1. *Plant height and Leaf area per plant of tobacco plant as affected by interaction effect of intra-row spacing and nitrogen fertilizer rates at Achura kebele, Wolaita Zone, Southern Ethiopia in 2017*

	Plant height(m)			
Nitrogen rate (kg/ha)		**Intra-row spacing (cm)**		
	40	45	50	55
0	0.83^f	0.86^f	0.93^f	0.91^f
40	1.4^e	1.51^d	1.46^{de}	1.45^e
60	1.81^{bcd}	1.68^{cde}	1.93^{bc}	1.96^{bc}
80	2.35^a	2.16^{ab}	1.91^{bc}	2.11^{ab}
LSD (0.05)	0.336			
CV (%)	12.8			
	Leaf area per plant(cm^2)			
Nitrogen rate (kg/ha)		Intra-row spacing (cm)		

	40	45	50	55
0	546^{i}	$56\ 1^{i}$	378^{j}	738^{h}
40	1190^{e}	1224^{e}	1020^{f}	1356^{d}
60	934^{g}	956^{fg}	1574^{c}	1332^{d}
80	1539^{c}	1674^{b}	1760^{a}	1790^{a}
LSD (0.05)	64.3			
CV (%)	3.3			

LSD =Least Significant Difference at 5% level; CV=Coefficient of Variation; Means in column followed by the same letters are not significantly different at 5% level of significance.

Yield Components and Yield

Green Leaf Yield per Plant (kg/plant)

The analysis variance indicated significant green leaf yield per plant difference due to the N effect and intra-row spacing as well as their interaction (table 2). The maximum (1.41kg plant^{-1}) green yield at 80 kg/ha N with 50 cm intra-row spacing and the minimum yield (0.55 kg plant^{-1}) found by using 0 kg /ha combined with 45 cm plant spacing. It is clear that the more number of leaves per plant and leaf size associated with increasing of yield per plant.

It indicated that increasing of N fertilizer and intra-row spacing up to its maximum point increases yield per plant. Similarly, Kozumplik and Lamarre (1979) postulated that leaves from wider spaced generally produce more leaf weight than those from closer spacing. This is because they were raised from environments that have limited or lower resources competition and thereby allowing them to accumulate more assimilates and thus more weight.

Green Leaf Yield per Hectare (kg/ha)

Data regarding green yield per hectors is presented in table of green yield per hectare was Significantly affected due to nitrogen and spacing as well as interaction effect. The maximum green yield (25636.4 kg/ha) was recorded from combination of 80 kg ha^{-1} and 55cm plant spacing on the other hand the least green yield (10000 kg /ha) was recorded from unfertilized treatments combined with 45 cm plant spacing. In general, green yield per hectare increased with increased N fertilizer with wider spacing. This might be due to less resource competition for light and nutrient. The result was in agreement with that of Kutjevo (2005) who reported that the saleable yield of the flue cared tobacco leaves is generally higher for those plants that are grown at wider Spacing. Moreover, Kozumplik and Lamrre(1997) reported that wider Spacing tobacco production generally result in negligible or no computation for resources between plants therefore allowing more assimilates to accumulate in leaves thus, more biomass which translate to the actual final cured leaf mass.

Table2. *Green leaf yield per plant, Green leaf yield per plant, Dry leaf yield per hectare and Total biomass per hectare as affected by interaction effect of intra-row spacing and N rates at Achura in Wolaita Zone, Southern Ethiopia in 2017.*

Nitrogen rate(kg/ha	Intra-row spacing (cm)	Green leaf yield (kg/plant)	Greenleaf yield(kg/ha)	Dry leaf yield (kg/ha)	Total biomass (kg/ha)
0	40	0.63^{h}	11454.5^{h}	1636.37^{hg}	43481^{h}
	45	0.55^{i}	10000^{i}	1428.57^{i}	42026.5^{i}
	50	0.72^{g}	13090.9^{g}	1870.13^{f}	45117.4^{g}
	55	0.65^{gh}	11818.2^{hg}	1688.31^{f}	43844.7^{hf}
40	40	1.3^{bcd}	23636.4^{bcd}	3376.62^{bcd}	55662.9^{bcd}
	45	1.12^{f}	20363.6^{f}	2909.09^{f}	52390.2^{f}
	50	1.13^{f}	20545.5^{f}	2935.06^{f}	52572^{f}
	55	1.15^{f}	20909.1^{f}	2987.02^{ef}	52935.6^{f}
60	40	1.17^{ef}	21333.3^{ef}	3047.62^{ed}	53359.9^{ef}
	45	1.25^{d}	22727^{d}	3246.75^{d}	54753.8^{cde}
	50	1.24^{de}	22545.5^{de}	3220.78^{d}	54572.0^{ed}
	55	1.2^{bcd}	22909.1^{cd}	3272.73^{cd}	54935.6^{cd}
80	40	$1.25.^{d}$	22727.3^{cd}	3246.7^{bcd}	54753.8^{cde}
	45	1.33^{bc}	24181^{bc}	3454.55^{bc}	56208.3^{bc}
	50	1.41^{a}	25636.4^{a}	3662.34^{a}	57662.9^{a}
	55	1.35^{ab}	24545^{ab}	3506.49^{ab}	56572.0^{ab}

LSD(0.05)		0.073	1333.9	190.56	1333.9
CV (%)		4.02	4.02	4.0	1.54

LSD =Least Significant Difference at 5% level; CV=Coefficient of Variation; Means in column followed by the same letters are not significantly different at 5% level of significance.

Total above Ground Biomass (Kg/Ha)

Analysis of variance showed that N- rate by intra-row spacing interaction had significant effect on total above ground biomass yield (table 2). The highest total biomass (57662.9 kg/ha) were associated with the interaction of application of 80 kg N /ha and using intra row spacing of 50 cm. The lowest total biomass (42026.5 kg/ha) was scored in the average interaction of 0Nkg/ha with intra row spacing of 45 cm. It is therefore clear that there is need for careful application of the optimum amount of nitrogen to avoid yield or quality penalties which would otherwise negatively affect farmers' income. The variability in the above ground dry biomass yield (kg/ha) in different rate of nitrogen and intra-row spacing might be because of comparatively less competition for resources in wider intra row spacing and increasing of nitrogen rate. This result is in agreement with findings of Highighi *et al* (2010), who reported that, increasing amount of nitrogen fertilizer leaf length and leaf width increased because nitrogen stimulate the bio synthesis and export of cytokine hormone from root to leaves that is used in increasing of cell division.

Wider spacing in tobacco production generally result in negligible or no competition for resources between plants therefore allowing more assimilates to accumulate in leaves thus more biomass which translates to the actual final cured leaf mass (Kozumplik and Lamarre1979). Narrower spacing tends to limit leaf expansion of the crops and therefore smaller leaf sizes result in reduced efficiency of photosynthesis and therefore biomass accumulation and finally the yields, however response to competition tends to vary due to differences in varietal morphology and physiology. Competition for light is more prevalent in narrow intra row spacing than wider ones because proportion of plants per unit area will be higher and each of the plants will be requiring more light for photosynthesis and this is critically important in that light is responsible for the production of ATP and NADPH and thus it becomes less available, leading to low light intensities and these products are not produced in adequate amounts (Randel, 2010).

Leaf Quality Analysis

Nicotine Content (%)

Analysis of variance on Nicotine content showed significant difference due to N fertilizer and plant spacing and their interaction (table 3). The highest nicotine content (1.845%) was recorded at N application rate of 80 kg N/ha with intra-row spacing of 50 cm between plants. However, the lowest nicotine content (1.215%) was recorded from plots those not nitrogen applied with an intra-row spacing's of 40 cm. This might be due to nicotine content in the leaf which is directly proportional to added nitrogen and intra-row spacing. Similar finding reported by (Critanini,2006) that closely spaced plants produce low nicotine content because of competition for nitrogen and since nitrogen is a key determinant factor determining nicotine content. It is considered that a nicotine level of 1.75 to 2.0% in FCV tobacco is most satisfactory. Also Collins and Hawks (1993) reported a reduction of alkaloid content as plant intra row spacing was reduced.

It is important that leaf composition in tobacco was showed to greatly vary according to differences in plant spacing and other growing practices. Closely spaced plants produce low nicotine content because of competition for nitrogen and since nitrogen is a key determinant factor determining nicotine content (Cristanini, 2006). Wider spacing result in produced plants having higher nicotine content due to significant reduction in intra specific competition for nutrients such as nitrogen (Elliot, 1990).

Sugar Content (%)

The interaction of N rate and plant spacing showed ($p<0.05$) significant effect on sugar content of the leaf. The highest (17.87%) sugar content was recorded for plants grown unfertilized on plots receiving with intra-row spacing of 50cm. But the lowest (11.37%) sugar content was recorded on N rate of 60 kg N/ha with intra-row spacing of 55cm as indicated in the study(table 3). There was decreasing of sugar, when increasing of N rate.

The result was agreed with Amanullan et al (2008) who showed that different N levels have significant effect on the leaf sugar. They noted that leaf reducing sugar was negatively related to N levels. Also Similar results reported by that the highest level of sugars was Observed in the control plot while minimum sugar was obtained when N was applied at the highest rate. Additionally another findings Cai and Pain (2003) who observed significant reduction in sugar the leaves of tobacco when N rate was increased. According to Rapper and Mc cants (2006), they concluded that lower invade quit nitrogen causes plants to synthesize starch prematurely and thus restricting nicotine production and favors starch accumulation.

Sugar content is inversely proportional to nitrogen availability. So in closer spaced plants because of competition for the mobile nitrogen nutrient, it becomes inadequately available and therefore resulting in low nicotine content levels and for the wider intra row spacing there is little or no competition for nitrogen such that it is available and this translates to higher levels of nicotine in the leaves (Yemmanne, 2013). However fluctuations in the level of nicotine in the leaves have got a bearing on the level of sugars or the ratio of sugars to nicotine.

As the nitrogen availability increases, there is usually a subsequent decrease in the sugar to nicotine ratio due to increased synthesis of nicotine. This is attributed to the fact that nitrogen is a component of the nicotine molecule so when it is available in the soil more nicotine will be produced in the plant hence reduction in the ratio.

Total Nitrogen content (%)

The analysis of variance showed ($p<0.05$) that there was significant difference among treatments and their interaction. The maximum (2.53) nitrogen content was recorded for nitrogen rate of 80 kg N / ha with intra-row spacing of 40 cm and the minimum value (1.83 and 1.85 %) recorded at ferments those no nitrogen applied plots combined with intra-row spacing of 40 cm and 45 cm(table 3). Laboratory obtained result reveals combination of treatments were laid in the acceptable zone of nitrogen contents of flue cured tobacco leaves. It is generally considered that flavor and taste of smoke is correlated with the nitrogenous constituents. Flue-cured tobacco containing 1.6 to 2.3% total nitrogen gives the most satisfying smoke. Higher nitrogen content of tobacco would result in, apart from curing difficulty, deep brown colored trashy leaf which shatters readily and it has flat-insipid tasting smoke. Generally high level of nitrogen is associated with high level of nicotine. Lower nitrogen content would result in `washed out', pale colored leaf, lacking in rich color characteristic of good tobacco.

Table3. *Nicotine content, Sugar content and Nitrogen content as affected by interaction effect of intra-row spacing and nitrogen fertilizer rates at Achura kebele, Wolaita Zone, Southern Ethiopia in 2017*

	Nicotine content (%)			
Nitrogen rate(kg/ha)		**Intra-row spacing (cm)**		
	40	45	50	55
0	1.215 ^{gh}	1.280^{f}	1.375^{e}	1.305^{fg}
40	1.35^{ef}	1.40^{e}	1.290^{g}	1.525^{cd}
60	1.475^{d}	1.57^{bc}	1.280^{g}	1.360^{ef}
80	1.500^{d}	1.625^{b}	1.795^{a}	1.845^{a}
LSD (0.05)	0.05 77			
CV (%)	1.85			
	Sugar content (%)			
Nitrogen rate(kg/ha)		Row spacing (cm)		
	40	45	50	55
0	17.52^{ab}	17.20^{b}	17 .87^{a}	12.15^{hi}
40	16.36^{e}	12.04^{i}	15.26^{d}	15.63^{d}
60	15.23^{d}	12.52^{gh}	13.12 ^{f}	11.37^{j}
80	14.60^{e}	12.33^{hi}	15.38^{d}	12.83^{fg}
LSD (0.05)	0.4189			
CV (%)	1.36			
	Nitrogen content (%)			
Nitrogen rate(kg/ha)		Row spacing (cm)		
	40	45	50	55
0	1.86^{f}	2.03^{cd}	1.88^{fg}	2.005^{de}
40	1.92^{efg}	2.03^{cd}	1.98^{def}	2.10^{c}
60	1.89^{fg}	1.99^{de}	1.85^{g}	1.96^{def}

80	2.53^{a}	2.26^{b}	1.83^{f}	2.28^{b}
LSD (0.05)	0.0955			
CV (%)	2.22			

LSD =Least Significant Difference at 5% level; CV=Coefficient of Variation; Means in column followed by the same letters are not significantly different at 5% level of significance.

Partial Budget Analysis

In this study the partial budget analysis was done by considering all variable costs and all benefits obtained from green leaf yield. Variable cost includes cost of fertilizer. Accordingly, during experimental period the fertilizer cost of urea fertilizer was 15 birr kg^{-1}.

The average market price of tobacco green leaf yield in local market was 4.70 ETB kg/ha. Partial budget analysis showed that highest net benefit (96602.86 birr ha^{-1}) was obtained in the treatment that received 80N kg ha^{-1} nitrogen and 50cm plant spacing, whereas the lowest net benefits (25200 birr ha-1) was obtained from the unfertilized treatment (Table 4). The net return was about 3.83 fold higher that the control. Therefore, to get maximum yield for farmers it is recommended to use 80kgN/ha with 50cm plant spacing.

Table4. *Partial budget analysis of Tobacco as influenced by nitrogen rate and intra row spacing*

N-F&PS	G Y (kg)	AGY	TVC	TR=AGYx FP	NR= TR-TVC
(0, 40)	11454.5	10309.050	-	28865.34	28865.34
(0, 45)	10,000	10309.050	-	25200	25200
(0, 50)	13090.9	11781.81	-	11781.81	3300.67
(0, 55)	11818.2	10636.380	-	29781.86	29781.86
(40, 40)	23636.4	21272.76	1305	59563.73	58258.73
(40, 45)	20363.6	18327.24	1305	78807.13	77502.13
(40, 50)	20545.5	18490.5	1305	79509.15	78204.15
(40, 55)	20909.1	18818.19	1305	80918.22	79613.22
(60, 40)	21333.3	19199.97	1950	82559.87	80609.87
(60, 45)	22727	20454.3	1950	87953.49	86003.49
(60, 50)	22545.5	20290.95	1950	87251.08	85301.08
(60, 55)	22909.1	20618.2	1950	88658.26	86708.26
(80, 40)	22727.3	20454.57	2610	87954.65	85344.65
(80, 45)	24181	21763	2610	93580.09	90970.09
(80, 50)	25636.4	23072.76	2610	99212.86	96602.86
(80, 55)	24545	22090.5	2610	94989.15	923779.15

N-F=Nitrogen fertilizer, PS=Plant spacing, GY=Green leaf yield, AGY=Adjusted green leaf yield, TVC=Total variable cost,

TR=Total revenue, FP=Field price, NR=Net revenue.

CONCLUSION

Crop production depends on genetic potential, cultural practices including soil fertility and climatic variables. Under specific agro-climatic conditions, yield and quality of a crop mainly depend on balanced nutrition. Soil in the study area is poor in fertility due to nutrient depletion, soil erosion, as well as some adverse soil conditions such as acidity, which reduce the efficiency of uptake of nutrients by plants.

This resulted in low production and food insecurity. More over improper nutrition leading to nutrient in balance in plant is a major factor contributing to low tobacco production. In this context field experiment was conducted during 2017 cropping season at Achura Keble to determining the optimum rate of nitrogen fertilizer and intra-row spacing for tobacco production. Treatments consisted of four levels of N rates (0, 40, 60 and 80 kg N /ha and four intra-row spacing (40, 45, 50 and 55 cm) combined in factorial arrangement and laid out in a randomized complete block design (RCBD) with three replication. The result showed that, crop phenology, growth, yield components, yields and quality parameters of tobacco were significantly influenced due to the N rates, intra-row spacing or/and their interactions. The results of the research was indicate increasing of intra-row spacing will increase weight and the surface of tobacco leaf and it implies high quality of yield in low densities. Also, there was a negative relationship between intra-row spacing (high density) and yield, but leaf quality is lower than low density.

Therefore, 50 cm intra-row spacing was better than 40 cm and 45 cm distance in terms of better leaf and quality of leaf tobacco. But leaf number, leaf emergence and days to flowering were not significantly affected by intra-row spacing. In general increasing rate of nitrogen increases crop phenology, growth, yield, yield components, quality and economic return. There were a dry leaf yield of 3662.34 kg/ha which was found by using a N fertilizer rate of 80kg/ha with intra row spacing of 50 cm. Hence it could be recommended that using of 80 kg/ha N and intra-row spacing of 50 cm between plants to get maximum yield in the study area. However; this study was under taken in single season and one location it is better to repeat in different location and season to reach remarkable recommendation.

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