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Effect of different methods of zinc application on yield and quality of flue cured virginia Tobacco

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Abstract

An experiment was conducted to find out the response of various methods of Zn application on the final produce and quality of the cured Virginia (FCV) tobacco (*Nicotiana tabaccum* L.) variety T.M 2008. Four different application methods i.e. Soil application at (3 and 6 kg Zn ha $^{-1}$), Foliar spray (0.25 and 0.5 kg Zn^{-1}), root dipping (2% and 5% Zn suspension) at the time of transplantation and Fertigation (3 and 6 kg Zn^{-1}) were used. The plot without Zn was regarded as control. Zn was taken from $ZnSO_4$ along with Nitrogen, Phosphorus and Potash in the form of compound fertilizer i.e. NPK (12:15:20). The data showed that maximum K concentration in leaf (34.43 g kg^{-1}), Zn in leaf (3.27 g kg^{-1}), nicotine content (2.81%), total sugars (15.51%) and chloride content (0.91%) were recorded in soil D2 treatment. Maximum green leaf yield (17190 kg ha^{-1}) and leaf yield after curing (3228 kg ha^{-1}) were recorded in soil D1 treatment while foliar D2 gave favorable leaf yield after curing (17120 kg ha^{-1}). The application of 6 kg ha $^{-1}$ Zn enhanced the K uptake and Zn in tobacco leaves as well as nicotine content and total sugars, while 3 kg ha^{-1} improved green leaf and leaf yield after curing. Conclusively, 3 kg as well as 6 kg Zn $^{-1}$ in soil is the optimum method of fertilizer application and can be recommended for higher yield and quality in tobacco leaves.

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Introduction

Tobacco belongs to family solanaccae with two species i.e. (*Nicotiana tabacum* L.) and (*Nicotiana rustica* L.) which are widely grown through out the world. *Nicotiana tabacum* L. is processed for the manufacturing of cigarettes, Cigars, while the (*Nicotiana rustica* L.) is used for many different purposes like snuff and hukka (Poustini and Shamel, 2001). This is very important crop in KPK region of Pakistan. Nonetheless recently its production has been declined due to improper and unbalanced fertilization particularly micronutrient deficiency. Zinc (Zn) is an important micronutrient for biological systems. It is essential for protein synthesis and carbohydrate metabolism (Broadley *et al.*, 2007), however its application in high concentration resulted in the inhibition of plant metabolism. Wang *et al.* (2007) substantiated that excess Zn inhibits seed germination, plant growth and root development and causes leaf chlorosis, therefore proper amount of Zn and appropriate Zn application method influenced the Zn availability and plant growth. Ahmad *et al.* (2001) substantiated that Zn application at the rate of 10.0 kg ha^{-1} produced maximum commercial cane sugar and sugar yield as compared to plots received 5 kg ha^{-1}. Additionally they also found that soil application of Zn was better in producing higher cane yield and sugar yield as compared to foliar application. Nonetheless in another study, the response of cucumber to Zn foliar application was better than soil application (Sarwer 1992). Furthermore, Begum *et al.* (2003) conducted an experiment on the response of Zn application in rice (cv. BR26) and reported that Zn application increased yield of straw. Using Dipping method of the roots of seedling in a suspension of 2% Zinc oxide for a period of 24 hours was found economical and its grain yield was maximum 3.80 t ha^{-1}. Cakmak (2008) concluded that using Zn as soil and foliar fertilizers greatly contribute to grain Zn concentrations. Zn application by aerial spray on leaves produced good results by giving much increased grain Zn concentration than the application through soil. These studies clearly indicated the importance of Zn application method and Zinc application rate. Moreover, mineral matter plays an important role in tobacco metabolism during its growth (Kastori, 1990). They are particularly important for the combustion process and quality of tobacco, because they affect temperature and combustion conditions and ash characteristics (Lazarevic´ *et al.*, 2012).

To our knowledge, no study has been reported regarding Zn application in tobacco. Therefore, the current study was carried (1) to ascertain the role of Zinc in yield and quality of tobacco, (2) to examine effect of different Zn application methods on tobacco yield and quality, (3) to investigate Zinc concentrations and application methods on nicotine, sugars, chlorides and potassium contents of tobacco.

Materials and methods

Tobacco (*Nicotiana tabacum* L.) variety T.M 2008 grown at the field of Tobacco Research Station Khan Garhi, Mardan during crop season 2010 as planting material to study the effect of Zinc applied by various methods on the yield and quality of Flue Cured Virginia (FCV). Factorial experiment with RCBD was used having two doses of Zinc ($ZnSO_4$) along with four replications. Four different methods i.e. Fertigation, foliar spray on leaves, soil application and root dipping in solution were used for Zn application and divided each in two doses (D1 and D2) along with control plot. Soil application at the rate of (3 and 6 kg Zn ha^{-1}), foliar spray on leaves (0.25 and 0.5 kg Zn ha^{-1}) and root dipping (2% and 5%) and Zn suspension at the time of transplantation and (3 and 6 kg Zn ha^{-1}) was used in Fertigation. A composite soil sample from a depth of 0-20 cm was taken and undergone analysis for various physio-chemical characteristics of the experimental site before conducting the experiment. To evaluate the method of Zn application on tobacco crop following parameters were measured:

'Zn' Concentration in leaf

Zinc concentration was determined with the help of Atomic Absorption Spectrophotometer using appropriate standards. First, the leaf samples were digested with Nitric acid (HNO_3) and perchloric acid ($HClO_4$). The perchloric acid solution was diluted, filtered and brought to volume with distiled water (Walsh and Schulte, 1977).

'K' concentration in leaf

After Curing leaves were dried and grounded by Willy mill and ashed method (Gaines and Mitchell, 1979). K concentration was determined by Flame photometer in the digests.

Green leaf yield

For getting green yield plot^{-1}, mature leaves were harvested in four subsequent pickings and were weighed separately for each treatment plot in kg ha^{-1}.

Cured yield

The cured leaf weight of each treatment was recorded after each picking and summed of the total cured weight of all pickings and calculated by the following formula:

$$\text{Leaf yield after curing (kg/ha)} = \frac{\text{Cured leaf x 1000cm}^2}{\text{Area harvested (16.2 m}^2\text{) x 1000kg ha}^{-1}}$$

Nicotine content

Nicotine content of the cured leaves was determined using gas chromatographic method (AOAC, 2000). The nicotine contents calculated by the following formula: -

$$\text{Nicotine content} = \frac{\text{V1 x N x 32.5}}{\text{Weight of sample}}$$

Where;

V1 = volume of titrate for non-acetylated aliquote

N = normality of perchloric acid

Total sugar

Sugars content of the cured leaves was determined by the method of Stellenbosch (2002).

Chloride

Method of Chapman and Pratt was used to determine chloride content of cured leaves (AOAC, 2000) by the following formula

$$\%\text{Cl} = \frac{\text{ml of AgNO}_3\text{ x 0.05N x Eq.wt.of Cl x 100 x 50}}{\text{1000 mL x aliquot x wt.of sample}}$$

Statistical analysis

ANOVA technique was used to analyze data and means were compared by LSD-test of significance (Steel *et al.*, 1997).

Results and discussion

Physico-chemical properties

The soil was clay loam in texture, nearly impartial in reaction, non saline in nature and somewhat calcarious, low in organic matter content (Table. 1) having slight pH and EC in soil. Moreover, the soil was low in Zn and available P.

Table 1. Physico-chemical properties of experimental soil.

Properties	Units	Values
Sand	%	9
Silt	%	15
Clay	%	76
Soil texture	-	Clay loam
pH (1:5)	-	7.80
EC (1:5)	dSm^{-1}	5.2
Organic matter	%	1.14
AB-DTPA Extractable Zn	µg g^{-1}	0.89
AB-DTPA Extractable Phosphorus	µg g^{-1}	0.99

Zn, K and Cl uptake in tobacco leaf

Statistical scrutiny of the data showed that different zinc application methods and doses significantly affected leaf zinc content. The M x D interaction (Figure 1a) and contrast between control vs rest was also significant.

Higher leaf zinc concentration was found in plots treated with soil zinc application followed by foliar zinc application whereas root dipping resulted in lower leaf zinc content. The treatment soil D_2 improved the Zn quantity in leaves of tobacco.

Figure 1(a) also indicated that leaf zinc increased as application dose was increased from half to full under fertigation, foliar and root dipping methods whereas, decreased in soil application method. Sharma and Katyal (1986) reported that grain yield was found to be significantly correlated with Zn content of grain and straw and aerial spray on leaves of Zn sulphate was a responsive emergency method. Moreover, Rehman (1993) reported that Zn aerial spray on leaves significantly increased tissue Zn, fruit, yield and vitamin C content in orange juice.

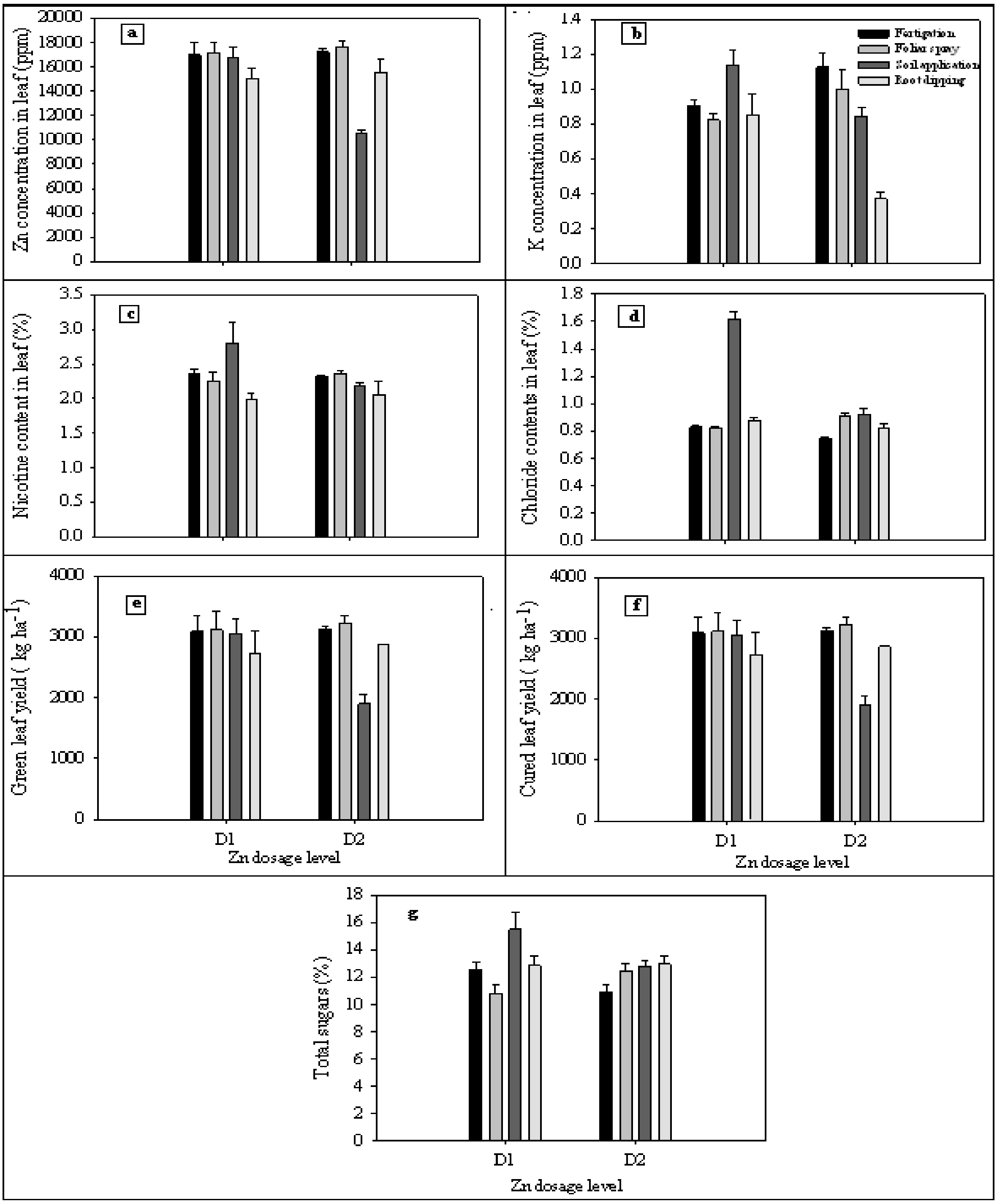

Fig. 1. Influence of different Zinc application methods and dose levels on (a) Zinc concentration in leaf, (b) K concentration in leaf, (c) Nicotine content in leaf, (d) Chloride content in leaf, (e) Green leaf in yield, (f) Cured leaf yield, (g) Total Sugars.

'K' concentration in leaf

Statistical analysis showed that different zinc application methods and doses significantly affected K content. K concentration was maximum (33.05 ppm) in plots treated with foliar zinc application followed by plots under fertigation treatment method. However, K concentration was lower in root dipping method (28.88 ppm). The significant M x D interaction indicated that K concentration decreased as zinc application rate was increased from half to full dose in all the four methods (Figure 1b). K concentration in tobacco leaves increased by different Zn application methods ranged from 24.93 to 34.43 g kg^{-1}. Parker *et al.* (1993) reported that increasing fertilizer rates increased the concentrations of N and alkaloids, while P and K rates did not affect yield and quality.

Nicotine content

The results revealed that Zinc application methods significantly improved the amount of nicotine content in leaves while the effect of doses remained non-significant (Figure 1c). The M x D interaction (Figure 1c) and contrast between control vs rest was significant. It revealed that nicotine content increased as zinc dose was increased in combination with foliar and root dipping method while decreased in combination with fertigation and soil application method. Kena and Kelsa (1990) observed that nicotine content increased significantly with increased N or K rates, also, application of 12 kg N or 10 kg K ha^{-1} should be applied to bring the nicotine content to an acceptable level (1.5%).

Chloride Content

Statistical analysis of the data showed that different zinc application methods significantly affected chloride content while the effect of doses was found non-significant (Figure 1d). Higher chloride concentration was found in leaves collected from plots treated with foliar zinc application followed by root dipping. Non-significant differences for chloride content were observed among different methods of Zn application (Figure 1d). Chari (1995) suggested the threshold value for chloride content is below 1.5% in a good and acceptable tobacco leaf. Akehurst (1981) reported that if the chloride content rises above 2.5%, the tobacco leaf is nearly incombustible.

Green leaf and cured leaf yield

Different zinc application methods and doses significantly affected green leaf yield. The M x D interaction (Figure 1e) was significant while the contrast between control vs rest was found non significant. Green leaf yield was maximum (17394 kg ha^{-1}) by foliar zinc application followed by fertigation method. The yield in tobacco increased by different Zn application methods ranged from 10570 to 17670 kg ha^{-1}. The application method soil D_1 improved the green leaf yield suggesting the nutrient requirements in tobacco leaves. Leaf zinc increased with increased dose under fertigation, foliar and root dipping methods of zinc application except soil application method (Figure 1e). Our results are in accord to the findings of Sanaullah and Zada (2004) that application of K @ 100 kg ha^{-1}. Zn @ 2 kg ha^{-1} and B @ 1 kg ha^{-1} significantly increased yield and most of the yield components.

Leaf yield after curing

Among application methods, foliar zinc application resulted in maximum crude leaf yield (3170 kg ha^{-1}) statistically similar with fertigation method in contrast to minimum (2474kg ha^{-1}) crude leaf yield by soil application (Figure 1f). Though the effect of doses was not significant however, full dose of zinc with all application methods resulted in lower crude leaf yield as compared to half dose. Figure 1(f) indicated that leaf zinc increased as application dose was increased from half to full under fertigation, foliar and root dipping methods of zinc application, whereas decreased in soil application method. These results suggested that the application of trace elements fertilizer should base on the characteristics of tobacco varieties, improve the yield and quality.

Nicotine and total sugar contents

The results illustrated that different methods of Zn application enhanced total sugar in tobacco leaves.

Statistical analysis of the data indicated that sugars content of tobacco are significantly affected by M and D (Figure 1g). Soil zinc application resulted in higher total sugar (14.15%) which was at par with root dipping in zinc followed by fertigation method (Figure 1g). Significant contrast between control vs rest indicated that treated plots resulted in higher total sugars as compared to control. Idrees (2001) reported that NPK fertilizer of 40:80:80 kg ha^{-1} showed good results and nicotine content and sugars were differed with significance by different doses of fertilizers.

Conclusions

On the basis of findings obtained, it was concluded that the soil application at the rate of 3 and 6 kg Zn per hectare along with basal dose of 50-60-80 kg ha^{-1} NPK (12:15:20) increased green and leaf yield after curing as compared to other methods of Zn application. Moreover, the quality parameters such as nicotine content and total sugar were significantly increased, along with Concentration of K, by soil application (6 kg Zn ha^{-1}) as compared with other application methods.

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