Research Article

# Early Pruning and Potash Fertilizer Improve the Recovery and Growth of Deeply Pruned Tea (*Camellia sinensis* L)

**Fayaz Ahmad[1]*, Noorullah Khan[1], Farrukh Siyar Hamid[1], Qamar uz Zaman[1], Shamsul Islam[1], Muhammad Abbas Khan[1] and Sair Sarwar[2]**

*[1]National Tea and High Value Crops Research Institute, Shinkiari-Mansehra, Pakiatan; [2]Land Resources Research Institute NARC Islamabad, Pakistan.*

**Abstract** | The experiment was conducted at National Tea and High Value Crops Research Institute, Shinkiari Mansehra during the years 2012-13 with the objectives to find out the most suitable time of pruning and doses of potash fertilizer for deep pruning of tea bushes and their subsequent efficient recovery and proper growth. The experiment was laid out in Randomized Complete Block Design with three replications. Mature tea plants (26 year old) of Qi-men variety were deeply pruned (30 cm from the ground level by completely defoliating the bushes) on five different dates i.e., November, December, 2012, January, February and March, 2013 having one month interval. Application of potash fertilizer @ 90,120 and 150 kg ha$^{-1}$ was also compared with control for studying its role in the recovery and growth of deeply pruned tea. The earliest shoot sprouting (April, 2013) was recorded in tea bushes pruned on November, 2012 and receiving potash fertilizer @ 150 kg ha$^{1}$ as compared to a19 days delay recorded in first shoot sprouting in tea bushes pruned on March, 2013 and receiving no potash fertilizer. Time of pruning significantly affected the shoot growth and it ranged from 54.75 cm (March, 2013) to 75.90 cm (December, 2012). The higher doses of potash fertilizer (150 kg ha$^{-1}$) significantly increased the shoot growth (70.56 cm) as compared to the control (60.53 cm). The interaction between time of pruning and levels of potash fertilizer for number of leaves per shoot was not significant, however tea bushes pruned on December 2012 and applied with potash fertilizer @ 150 kg ha$^{-1}$ produced maximum number of leaves per shoot (24.53) and was followed by December pruning (24.53 leaves per shoot) with the application of potash @ 120 kg ha$^{-1}$. Shoot thickness was also significantly affected by time of pruning and application of potash fertilizer. Early deep punning of tea bushes in the dormant season (December) and application of potash fertilizer increased the foliage biomass production by 47.26% as compared to late pruning (March) and without the application of potash fertilizers. On the basis of these findings, it can be concluded that deep pruning of tea during the month of December and application of potash @ 150 kg ha$^{-1}$ resulted in e best recovery and growth of deeply pruned tea bushes under the climatic conditions of Mansehra-Pakistan.

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***Correspondence** | Fayaz Ahmad, National Tea and High Value Crops Research Institute, Shinkiari-Mansehra, Pakistan; **Email:** fasafiparc@gmail.com
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## Introduction

Tea *(Camellia sinensis)* is one of the most important beverages used worldwide and is grown in about 30 countries of the world (Adnan et al., 2013). Its origin is South Eastern China but currently it is cultivated in many tropical and subtropical regions of the world and has more than 82 genetically differ-

ent species (Krafczyk and Glomb, 2008; Sultana et al., 2008; Akhlas et al., 2003). Tea plantation contributes greatly to the economy and job opportunities for many Asian and African countries due to its large-scale production, trade and consumption (NTHRI, 2010).

Growth and productivity of tea bushes are influenced by the genetic makeup of tea cultivars as well as by the external factors comprising of soil and climatic conditions, cultural practices and pest and disease management techniques (Rishiraj, 2011). Owuor et al. (2011) reported that tea quality is mainly affected by cultivars, environment, cultural practices and tea processing techniques.

In tea crops husbandry, pruning is one of the most important and necessary operation to keep the tea bush continuously in vegetative phase (Li et al., 2011). Besides regular annual light pruning, tea plantation is deeply pruned after eight to ten years to rejuvenate the tea bushes with passage of time as tea is a long lived plant species. The pruning operation is aimed at keeping the size and vegetative vigor of the plant in a condition most conducive for maximum vegetative growth and production. Pruning is the best management practice available to induce frame formation. Good recovery of tea bushes from pruning depends on the severity and style of pruning, condition of roots system regarding the starch reserves levels, time of pruning, health status of tea bush, nutritional condition of the soil, temperature and rainfall distribution (TRIT, 2004). Bore et al. (2003) reported that recovery of the tea bush after deep pruning is greatly dependent on the time of pruning as well as on the carbohydrate balance of root and shoot system. Hajra (2001) reported that under the climatic condition of North East India, the best time of tea pruning is December-January when the starch reserve in the roots is fully developed. Fayaz et al. (2014) also recommended the dormant period pruning (December-January) as the most suitable times for the light pruning/skiffing of tea bushes under the climatic conditions of Shinkiari, Mansehra to get higher productivity. Qamar et al. (2011) reported highest shoot growth (71.33 cm) and fresh leaves production from tea plantation pruned in December. Hamid et al. (2000) also reported maximum plucking points in tea bushes pruned in early November and receiving 240 kg N $ha^{-1}$.

The recovery and growth of tea bushes after deep pruning is also highly influenced by the nutritional status of the soil and plant and particularly the potassium deficiency has a great effect on plant recovery levels. Potassium helps in the development of healthy frames of tea bush, which is necessary for sustainable production of tea plantation (Kumar et al., 2015). After nitrogen, potassium is the second most important and vital nutrient for tea crop. It is highly mobile in the plant tissues and promotes the translocation of carbohydrates to new young shoots (Ranganathan and Natesan, 1985). Ranganathan (1982 b) recorded a decline in the production of new flush and poor recovery after pruning and ultimate death of tea plants due to potassium deficiency. Singh and Misra, (2009) recommended application of NP and K in the ratio of 2:1:2 or 2:1:3 to mature tea plantation and the doses of K application ranged from 90-165 $kgha^{-1}$ based on the productivity and available potassium status in the soil. Verma and Pund, (2014), Singh and Sunil, (2018) recommended high rate of potassium (Nitrogen and Potash ($K_2O$) at the ratio of 1:2) in the pruned year to protect the tea bushes from new attack of shot hole borer. The potash requirement of tea crop is comparatively higher and results of various fertilizer trials indicated positive response of tea bushes to K application during all the growth stages of tea plants. Potassium is also effective in imparting tolerance to biotic and abiotic stresses (Jessy, 2011).

The present study was conducted to find out the most suitable time for deep pruning of tea bushes and appropriate level of potash fertilizer for good recovery, growth and productivity of tea under the climatic conditions of Shinkiari, Mansehra.

## Materials and Methods

The present study was conducted during the years 2012-13 at National Tea and High Value Crops Research Institute, Shinkiari (Mansehra), is located at altitude of 1000 m from sea level. The area lies between Latitudes 34° 20' and 34° 30' North and Longitude 73° 5' and 73° 20'. The experiment was laid out in Randomized Complete Block Design with three replications. Mature tea bushes of Qi-men variety were deeply pruned manually with shears at 30 cm height from the ground level by removing all the foliage. Pruning was done on five different dates with one-month interval. All the pruning dates falls in dormant growth period under the local climatic conditions of Shinkiari, Mansehra. For studying the role

of potassium in the recovery and growth of pruned tea, three different levels (90, 120 and 150 kg ha-1) of potassium element were compared with control by application of Potassium Sulphate. Nitrogen and phosphorous were kept constant and were applied @ 200 and 60 kg $ha^{-1}$respectively by using fertilizer sources of Ammonium sulphate and Di-ammonium phosphate. Soil pH of the experimental plot was recorded as 4.96, 5.12 and 5.64 for 0-15 cm, 16-30 cm and 31-45 cm soil depth respectively. The Climatic data of the experimental site during the study period were also recorded (Table 1). The experiment was arranged in Randomized Complete Block Design with four replications. Detail of treatments is as under.

**Factor A:** *Pruning timings*
**Factor B:** *Potassium levels (Kg $ha^{-1}$)*

| Factor A | | Factor B | |
|---|---|---|---|
| $D_1$ | 25th November 2012 | $K_0$ | Control |
| $D_2$ | 25th December 2012 | $K_1$ | 90 |
| $D_3$ | 25th January 2013 | $K_2$ | 120 |
| $D_4$ | 25th February 2013 | $K_3$ | 150 |
| $D_5$ | 25th March 2013 | | |

The experimental tea plots were managed through manual weeding and irrigation in the months of May and June through flood irrigation system. Data were recorded on date of first shoot spouting, shoots growth (cm). Number of leaves per shoot, shoot thickness (mm) and pruning weight of foliage (kg ha-1). Data were analyzed by analysis of variance techniques (ANOVA) and was subsequently followed by LSD test using software Statistix 8.1. (McGraw-Hill, 2008)

## Results and Discussion

### *Date of shoot sprouting*

Variation was recorded in times of first shoot sprouting as affected by different pruning timings and levels of potash fertilizer (Table 2). The earliest shoot sprouting on 16th April, 2013 was recorded in tea bushes pruned on 25th November, 2012 and applied with potash fertilizer @ 150 kg $ha^{-1}$, while tea bushes pruned on 25th March, 2013 and receiving no potash fertilizer showed the delayed shoot sprouting (5th May, 2013). It was found that the delay in the time of sprouting was linearly correlated with delay in time of pruning. The higher dose of potash fertilizer (150 kg $ha^{-1}$) recorded early sprouting as compared to other levels. The delay in sprouting of shoots in late pruned tea bushes might be due to availability of shorter time between deep pruning operation (removing the apical dominance) and delayed development of axillary buds on shoots. Bore et al. (2003) also reported variation in the recovery of tea bushes after deep pruning as affected by different pruning timings. In the current study, good recovery of tea bushes applied with potash fertilizer ascertains the vital role of potassium mineral in the recovery of tea bushes after deep pruning as potassium is the second most important nutrient for sustainable productivity of tea plants (Ranganathan and Natesan, 1985). Potassium deficiency leads to decline in new shoot production, poor recovery and even death of tea plants (Ranganathan, 1982 b). Islam et al. (2017) also reported that potassium is required in large quantities and is involved in almost all biological reactions and is the second major nutrient for tea plant growth after nitrogen.

### *Shoot growth*

It is evident from Tables 3 and Table 4 that both the time of pruning and potash levels significantly ($P<0.0001$) affected the shoot growth. Among the times of pruning, the shoot growth ranged from 54.75 cm (25th March, 2013) to 75.90 cm (25th December, 2012). The grand mean for shoot growth under time of pruning was 65.74 cm. It was found that the shoot growth increased with an increase in potash level and the higher doses of potash fertilizer (150 kg $ha^{-1}$) recorded the maximum shoot growth (70.56 cm) as compared to the control (60.53 cm). However, the interaction between time of pruning and potash levels was non-significant (Table 2) and the maximum shoot growth (84.20 cm) was found in the tea bushes pruned on 25th December, 2012 and applied with potash fertilizer @ 150 kg $ha^{-1}$, while tea bushes pruned on 25th March, 2012 and receiving no potash fertilizer exhibited minimum shoots growth (52.27cm). In the current study it was found that the early pruning of tea bushes in the dormant period and application of higher levels of potash fertilizer produced better results regarding the recovery and growth of tea bushes after deep pruning operation. Fayaz et al. (2014) also reported that the dormant period (December-January) is the most suitable times for the pruning/skiffing of tea bushes under the climatic conditions of Shinkiari, Mansehra. The results also agree with the findings of Qamar et al. (2011) who reported highest shoot growth (71.33 cm) and fresh leaves production from tea plantation pruned in the month of December.

**Table 1:** *Meteorological data of the experimental site.*

| Month | Year 2012 | | | | Year 2013 | | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature (°C) | | Relative Humidity (%) | Rainfall (mm) | Temperature (°C) | | Relative Humidity (%) | Rainfall (mm) |
| | Min. | Max. | | | Min. | Max. | | |
| January | - 1.40 | 12.90 | 55.09 | 45.31 | 2.20 | 18.00 | 52.40 | 21.90 |
| February | 0.90 | 14.50 | 58.02 | 90.69 | 4.30 | 17.20 | 61.25 | 211.80 |
| March | 6.50 | 20.00 | 67.80 | 137.00 | 7.90 | 22.90 | 65.90 | 115.40 |
| April | 5.40 | 26.20 | 52.95 | 120.60 | 10.90 | 25.80 | 63.45 | 0.00 |
| May | 12.00 | 31.00 | 46.90 | 49.60 | 14.50 | 32.20 | 51.23 | 63.70 |
| June | 16.90 | 37.00 | 41.20 | 6.36 | 19.00 | 35.00 | 52.85 | 124.90 |
| July | 18.80 | 34.70 | 67.45 | 131.90 | 21.10 | 32.30 | 67.20 | 362.40 |
| August | 20.70 | 32.20 | 72.20 | 392.40 | 21.40 | 32.00 | 69.00 | 200.00 |
| September | 16.80 | 29.00 | 75.85 | 266.79 | 17.20 | 30.40 | 60.10 | 176.20 |
| October | 9.10 | 27.40 | 52.50 | 6.90 | 14.10 | 29.20 | 43.50 | 25.30 |
| November | 5.70 | 24.00 | 50.70 | 42.20 | 5.50 | 22.30 | 34.50 | 22.70 |
| December | 3.60 | 18.30 | 57.70 | 66.42 | 3.00 | 20.10 | 23.50 | 0.00 |

**Source:** *Report of Agro-meteorological station of National Tea and High Value Crops Research Institute (NTHRI), Shinkiari Mansehra 2012-13.*

**Table 2:** *Interaction between time of pruning and different doses of potash fertilizer for recovery and growth of deeply pruned tea.*

| Pruning Timings (D) x Potassium Levels (K) | Date of shoot sprouting | Shoot growth (Cm) | Number of leaves per shoot | Shoot thickness (mm) | Pruning weight (Kg $ha^{-1}$) |
|---|---|---|---|---|---|
| $D_{1x}$ $K_0$ | 19th April | 63.83 | 15.23 | 3.94 | 14819.33 |
| $D_{1x}$ $K_1$ | 18th April | 70.47 | 19.23 | 4.30 | 16489.21 |
| $D_{1x}$ $K_2$ | 18th April | 69.53 | 18.17 | 4.51 | 16564.16 |
| $D_{1x}$ $K_3$ | 16th April | 75.57 | 21.43 | 4.74 | 17395.52 |
| $D_{2x}$ $K_0$ | 22ndt April | 67.20 | 16.50 | 4.31 | 14418.45 |
| $D_{2x}$ $K_1$ | 21st April | 73.62 | 20.33 | 4.78 | 16784.53 |
| $D_{2x}$ $K_2$ | 21st April | 78.60 | 22.80 | 4.73 | 17730.08 |
| $D_{2x}$ $K_3$ | 20th April | 84.20 | 24.53 | 4.92 | 18917.15 |
| $D_{3x}$ $K_0$ | 25th April | 61.27 | 15.17 | 3.79 | 13528.59 |
| $D_{3x}$ $K_1$ | 25th April | 62.30 | 16.73 | 4.12 | 14745.61 |
| $D_{3x}$ $K_2$ | 24th April | 69.77 | 17.17 | 4.31 | 15467.93 |
| $D_{3x}$ $K_3$ | 24th April | 68.83 | 16.53 | 4.46 | 14697.73 |
| $D_{4x}$ $K_0$ | 26th April | 58.10 | 15.20 | 3.85 | 11952.63 |
| $D_{4x}$ $K_1$ | 26th April | 60.93 | 16.40 | 3.97 | 13709.69 |
| $D_{4x}$ $K_2$ | 25th April | 65.70 | 17.30 | 4.08 | 14701.24 |
| $D_{4x}$ $K_3$ | 25th April | 65.87 | 16.20 | 4.16 | 14479.50 |
| $D_{5x}$ $K_0$ | 5th May | 52.27 | 12.57 | 3.36 | 9976.21 |
| $D_{5x}$ $K_1$ | 5th May | 54.20 | 13.50 | 3.66 | 11037.30 |
| $D_{5x}$ $K_2$ | 2nd May | 54.20 | 14.83 | 3.57 | 13381.54 |
| $D_{5x}$ $K_3$ | 2nd May | 58.37 | 14.43 | 3.89 | 13754.31 |
| G. Mean | - | 65.74 | 17.21 | 4.17 | 14728 |
| LSD at α 0.05 | - | NS | NS | NS | NS |

Application of potassium helped in the production of healthy frames of tea bush as it promotes development of young shoots due to translocation of carbohydrates to growing sites (Kumar et al., 2015; Ranganathan and Natesan, 1985).

*Number of leaves per shoot*

Significant (P<0.0001) variability was recorded for number of leaves per shoots as affected by different times of pruning and levels of potash fertilizers (Table 3 and Table 4). Deep pruning of tea bushes on 25th December, 2012 produced significantly high number of leaves per shoots (21.04) and was followed by 25th November 2012 pruning with production of 18.51 leaves per shoot, while the late pruning (25th March, 2013) recorded the minimum number of leaves (13.83) per shoot. Potassium application also significantly increased the number of leaves per shoots with highest number of leaves of 18.62 leaves per plant recoded in 150 kg $ha^{-1}$ as compared to the minimum leaves of 14.93 recorded in control plots. However, the differences among the potash levels were non-significant (Table 4). The interaction between time of pruning and levels of potash for number of leaves per shoot was not significant (Table 2). Tea bushes pruned on 25th December 2012 and applied with potash fertilizer @ 150 kg $ha^{-1}$ produced maximum number of leaves per shoot (24.53) and was followed by 25th December pruning (24.53 leaves per shoot) with the application of potash @ 120 $ha^{-1}$, while tea bushes pruned on 25th March and receiving no potash fertilizer produced minimum number of leaves per shoot (12.57). These results agree with the findings of Singh and Misra (2009) who also recommended K dose ranging from 90-165 kg$ha^{-1}$for mature tea plants.

*Shoot thickness*

It was found that among the times of pruning, the thickest of shoot diameter of 4.68 mm was recorded in tea bushes pruned on 25th December 2012 as against the thinnest shoot diameter of 3.62 mm recorded in tea bushes pruned on 25thMarch, 2013 (Table 3). A generally decline trend was observed in shoot thickness with delaying the pruning time from November to March. Time of pruning is one of the factors in satisfactory recovery of tea bushes from pruning (TRIT, 2004). Application of potash fertilizer also improved the shoot thickness (Table 4). A linear increase in shoot thickness was observed with increase of potash levels from 90 to 150 Kg $ha^{-1}$. These results are in agreement with Jessy (2011) who also reported a positive response of tea bushes to K application during all growth stages of tea plants.

**Table 3:** *Recovery and growth response of deeply pruned tea as affected by different times of pruning.*

| Date of Pruning | Shoot growth (Cm) | Number of leaves per shoot | Shoot thickness (mm) | Pruning weight (Kg $ha^{-1}$) |
|---|---|---|---|---|
| November ($D_{1)}$ | 69.85 b | 18.51 b | 4.37 b | 16317 a |
| December ($D_{2)}$ | 75.90 a | 21.04 a | 4.68 a | 16963 a |
| January ($D_{3)}$ | 65.54 c | 16.40 b | 4.17 bc | 14610 b |
| February ($D_{4)}$ | 62.65 c | 16.27 b | 4.01 c | 13711 b |
| March ($D_{5)}$ | 54.75 d | 13.83 c | 3.62 d | 12037 c |
| Grand mean | 65.74 | 17.21 | 4.17 | 14728 |
| LSD at α 0.05 | 3.8546 | 2.3092 | 0.2764 | 1560.80 |

*Means followed by different letter are significantly different from each other.*

**Table 4:** *Recovery and growth response of deeply pruned tea as affected by different Potassium levels.*

| Potassium levels | Shoot growth (Cm) | Number of leaves per shoot | Shoot thickness (mm) | Pruning weight (Kg $ha^{-1}$) |
|---|---|---|---|---|
| 0 kg $ha^{-1}$ ($K_0$) | 60.53 c | 14.93 b | 3.84 c | 12939 b |
| 90 kg $ha^{-1}$ ($K_1$) | 64.30 b | 17.24 a | 4.16 b | 14553 a |
| 120 kg $ha^{-1}$ ($K_2$) | 67.56 b | 18.05 a | 4.23 ab | 15569 a |
| 150 kg $ha^{-1}$ ($K_3$) | 70.56 a | 18.62 a | 4.43 a | 15849 a |
| Grand mean | 65.73 | 17.21 | 4.16 | 14727.50 |
| CV % | 10.12 | 14.30 | 9.25 | 11.34 |
| LSD at α 0.05 | 3.4476 | 2.0654 | 0.2473 | 1396.00 |

*Means followed by different letter are significantly different from each other.*

*Pruning weight*

After one-year growth from deep pruning, the tea bushes in experimental plots were top pruned (75 cm from ground level) and the fresh pruning weight of the various treatments was calculated to compare the effect of time of pruning and potash fertilizer on the growth and biomass production of tea. It was found that fresh pruning/foliage weight of tea bushes was affected significantly by both pruning times and levels of potash fertilizer. Maximum pruning weight (18917.15kg $ha^{-1}$) was produced by tea bushes pruned on 25th December 2012 and applied with potash fertilizer @ 150 kg $ha^{-1}$. Tea bushes pruned on 25th March in control treatment showed minimum fresh pruning weight (9976.21 kg $ha^{-1}$). Early deep punning in the dormant season and application of potash fertilizer

increased the foliage production 47.26% as compared to late pruning with no application of potash fertilizers. Hajra (2001) reported the December-January pruning of tea bushes as the best time under the climatic condition of North East India as the starch reserve in the roots is fully developed. Hamid et al. (2003) also recorded the highest plucking points in tea bushes when pruned in dormant season (November) and receiving 240 kg N $ha^{-1}$.

## Conclusion

On the basis of findings in the current study, it is concluded that deep pruning of tea bushes in the dormant season (November-December) and application of potash fertilizer @ 150 kg $ha^{-1}$ give better results in the recovery and growth of tea bushes under the climatic conditions of Shinkiari, Mansehra-Pakistan.

## Author's Contributions

Fayaz Ahmad, Noorullah Khan, F.S Hamid, Qamar uz Zama, Shamsul Islam, Muhammad Abbas Khan and Sair Sarwar conceived and designed the experiment. Fayaz Ahmad and Noorullah Khan carried out the experiment collected and analyzed the data and wrote the paper. F.S Hamid, Qamar uz Zama, Shamsul Islam, Muhammad Abbas Khan and Sair Sarwar provided technical support at every stage of the experiment and critical reviewed and revised the article.

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