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Influence of Different Application Amounts of Potassium Fertilizer on the Dynamics of Nitrogen Nutrition for Soil and Plants in the Jujube Orchards

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ABSTRACT
Through taking four-year direct-seeding close-planting jun-jujubes as materials and studying the influence of different application amounts of potassium fertilizer on the dynamics of nitrogen nutrition of soil and plants in jujube orchards, the result shows that different application amounts of potassium fertilizer will reduce soil alkali-hydrolyzable nitrogen content to different degrees. Soil alkali-hydrolyzable nitrogen content in different soil depths is always relatively low at the stage before leaf expansion and relatively high at blossom stage or fruit-set stage. There is an obvious linear negative correlation between the application amount of potassium fertilizer and soil alkali-hydrolyzable nitrogen content in 0-20cm depth at the stage before leaf expansion (r = -0.8769*). The application amount of potassium fertilizer is positively correlated with soil alkali-hydrolyzable nitrogen content in 20-40 cm depth at fruit-set stage remarkably (r = 0.95678*). The application amount of potassium fertilizer is negatively correlated with soil alkali-hydrolyzable nitrogen content in 40-60 cm depth at fruit maturation stage exponentially (r = -0.9835**). Applying 30 kg/667 m^2 of potassium fertilizer is beneficial to the absorption and accumulation of nitrogen in fruit branches before fruit-set stage. With regard to the different organs of jujubes at different growth stages, applying potassium fertilizer appropriately can effectively promote the nitrogen absorption of jujube plants, while applying potassium fertilizer excessively will curb the nitrogen absorption of jujube plants. The application amount of potassium fertilizer is significantly correlated with the nitrogen content in jujube secondary branches at the stage before leaf expansion (r = 0.9823**), obviously correlated with total nitrogen content in roots (r = 0.9673*), positively correlated with jujube leaves and total nitrogen content in roots at blossom stage remarkably (r = 0.9513*, 0.9456*) and notably correlated with total nitrogen content in secondary branches at fruit-set stage (r = 0.9455*).

Key words: Jujube, potassium fertilizer, nitrogen, soil and plants, dynamics

INTRODUCTION

Jujube trees are one of special fruit trees in China, called Chinese jujube (*Zizyphus jujuba* Mill.) abroad. Jujubes belong to *Ziziphus Mill.* plant of Rhamnaceae (Very and Sentenac, 2003). As a kind of special fruit tree resource and distinctive dominant tree species, jujube trees are characterized by easy cultivation, strong adaptability, bearing fruit early, quick gains and good market prospect. Jujubes have better quality in Xinjiang equipped with unique climate characteristics.

Potassium is an essential nutrition element, whose contents are only lower than that of nitrogen in plants. The contents of potassium occupies 5-8% of dry weight of plants. Potassium can involve in a variety of biochemical process, such as adjusting cell turgor, maintaining the charge balance of cells, regulating the activity of various enzymes and participating in protein synthesis (Grabov, 2007). The lack of potassium will severely impact the photosynthesis of plants and chlorophyll synthesis, cause tissue atrophy and do harm to the normal growth of plants (Zhao *et al*., 2001; Ashley *et al*., 2006). In addition, an appropriate amount of potassium ions are beneficial to strengthen the resistance of plants to the stresses of the adverse environment. For instance, a moderate amount of potassium is beneficial for plants to adapt to drought conditions (Li *et al*., 2011; Song and Su, 2013), salt stress (Mian *et al*., 2011; Bose *et al*., 2014; Song *et al*., 2014) or low-temperature stress (Rai *et al*., 2008; Song *et al*., 2015). In order to meet the needs of normal growth, plants have to efficiently absorb an appropriate amount of potassium ions from soil. The relationship among the application amount of potassium fertilizer, soil fertility, plant nutrition and rice yield in a rice experiment, many scholars including, Chen *et al*. (2011) pointed out that the application amount of potassium fertilizer was negatively correlated with soil alkali-hydrolyzable nitrogen content and rapidly available phosphorus content obviously. Through conducting studies, many scholars including, Xing *et al*. (2014) found that applying potassium fertilizer and kalium nitrate fertilizer through water spraying had promotive effect on the growth of tobacco plants at vigorous growing stage and round top stage and influenced nitrate nitrogen and ammonium nitrogen content in soil to different degrees. Many scholars held the opinion taking potassium ions as positive ions could accelerate the absorption and transport of nitrate nitrogen. Serving as a type of pump of nitrate nitrogen, potassium ions could effectively impact nitrogen metabolism. According to the research result, many scholars including, Hannan (2014) thought that excessive amounts of potassium and ammonium ions were significantly antagonistic in grapes. In plants, total nitrogen is manifested in the form of amide and amino acid apart from nitrate nitrogen and ammonium. Therefore, total nitrogen contents can more represent the absorption and accumulation amount of nitrogen in plants.

Xinjiang is a large province, where jujubes are planted and jun-jujubes are the main cultivar of jujubes. Studying the influence of potassium fertilizer on the nitrogen absorption of jun-jujubes has a very profound significance. Some scholars have studied the relationship between the functions of potassium and nitrogen regarding other plants (Bleleski and Johnson, 1972; Cui *et al*., 2011; Liu *et al*., 2003), but seldom conducted relevant studies on jujubes. This research takes the typical direct-seeding close-planting young jun-jujube orchards in Xinjiang as research objects and conducts studies on the influence of different application amounts of potassium fertilizer on the nitrogen absorption and distribution of jun-jujube plants, so as to provide reference basis for establishing reasonable fertilization system for close-planting jujube orchards in Xinjiang.

MATERIALS AND METHODS

The experiment was carried out in Alar Farm of the First Agricultural Division of Xinjiang Production and Construction Corps, where tested materials were biennial direct-seeding close-planting jun-jujubes and adopted the method of wide-and-narrow row planting with space between plants 0.5 m×0.5 m×l.5 m. The experimental area belongs to the type of typical continental extremely arid desert climate, where the soil is sandy soil. According to the test result of basic soil fertility, alkali-hydrolyzable nitrogen content was 56 mg kg^{-1}, rapidly available phosphorus content 8 mg kg^{-1} and rapidly available potassium content 61 mg kg^{-1}. When the soil was defrosted in spring, 30 kg/667 m^2 of urea and 40 kg/667 m^2 of calcium superphosphate was applied for topdressing before turning green.

The application of potassium fertilizer completely adopted randomized blocks design with four treatments, which applied 15 kg/667 m^2 (T1), 30 kg/667 m^2 (T2), 45 kg/667 m^2 (T3) and 0 kg/667 m^2 (CK) of potassium sulphate, respectively in soil at the fruit maturation stage of jujubes. Each treatment was repeated three times. After experimental treatments, various organs (primary stem, annual branch, secondary branch, perennial branch, fruit branch, leaf and root of plants and soil samples of different depths were collected at the stage before leaf expansion (March, 25), blossom stage (May, 31), fruit-set stage (August, 5) and fruit maturation stage (October, 4), respectively of jujube trees after jujube trees lived through the winter naturally. After being collected, plant samples were cleaned, cut up, killed out for 15 min under 105, dried to constant weight under 70 and smashed for nutrition analysis. With regard to the collection of soil samples, soil depth was divided into four groups, namely 0-20, 20-40, 40-60 and 60-80 cm. After collection, soil samples were air-dried and passed through the sifter with bore diameter 1 mm.

Soil alkali-hydrolyzable nitrogen was measured with the method of alkaline hydrolysis diffusion. The total nitrogen of plants was measured by H_2SO_4-H_2O_2 digestion-Kjeldahl determination.

Data analysis: The data measured was analyzed and processed by means of the software Excel2007 and SAS9.4.

RESULTS

Dynamics of soil alkali-hydrolyzable nitrogen contents under different potassium replying number: From Fig. 1a, it can be seen that soil alkali-hydrolyzable nitrogen content at 0-20 cm depth decreases before rising at the stage before leaf expansion and blossom stage of jujubes, rises before decreasing at fruit-set stage and presents the variation tendency of "down-up-down" at fruit maturation stage with the increase of potassium application amounts. It shows that applying excessive potassium fertilizer will curb the accumulation of alkali-hydrolyzable in shallow depths in the

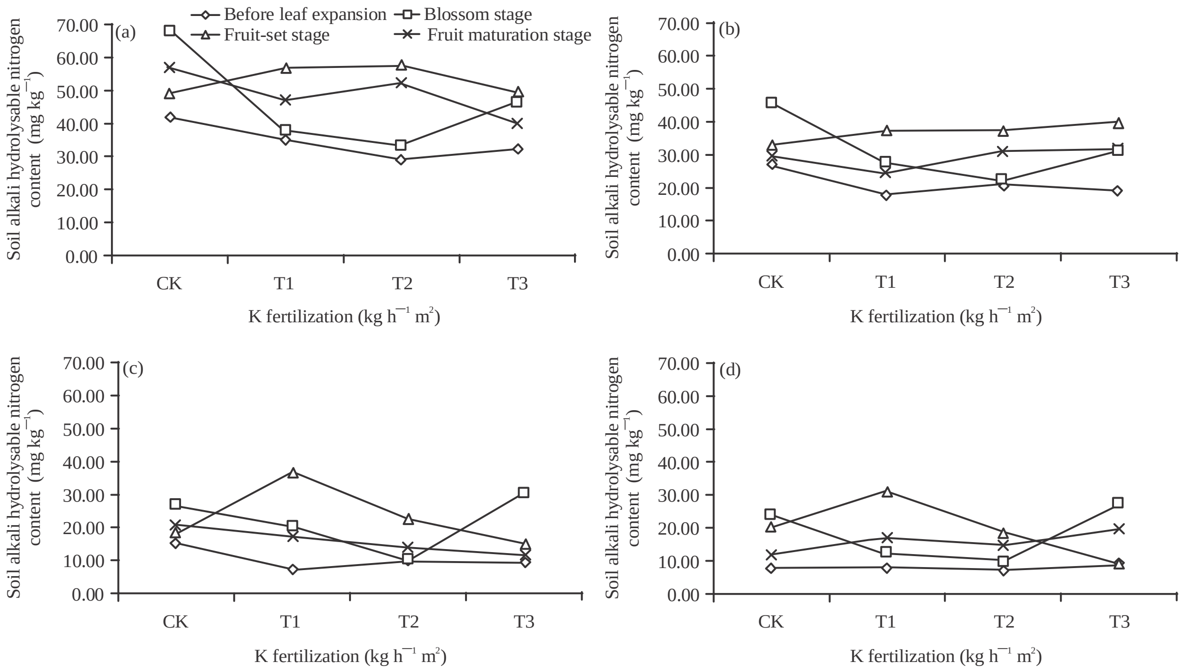

Fig. 1(a-d): Dynamics of soil alkali hydrolyzable nitrogen content in (a) 0-20, (b) 20-40, (c) 40-60 and (d) 60-80 cm depth under different potassium replying number

case of abundant potassium content in soil. When potassium fertilizer is not applied, soil alkali-hydrolyzable nitrogen content from high to low is at blossom stage, fruit maturation stage, fruit-set stage and the stage before leaf expansion, when applying 15 and 30 kg/667 m^2 of potassium fertilizer, soil alkali-hydrolyzable nitrogen content from high to low is all at fruit maturation stage, blossom stage, fruit-set stage and the stage before leaf expansion, when applying 45 kg/667 m^2 of potassium fertilizer, soil alkali-hydrolyzable content from high to low is at fruit-set stage, blossom stage, fruit maturation stage and the stage before leaf expansion; soil alkali-hydrolyzable nitrogen content is relatively high at fruit-set stage.

From Fig. 1b, it can be noticed that soil alkali-hydrolyzable nitrogen contents in 20-40 cm depth presents the variation tendency of "down-up-down" at the stage before leaf expansion and fruit maturation stage of jujubes, decreases before rising at blossom stage with a large decreasing amount and small rising amount, reaches the minimum value under the treatment of T_2 (applying 30 kg/667 m^2 of potassium fertilizer) and comes to the maximum value in the control group with the increase of potassium application amounts. With the increase of potassium application amounts, soil alkali-hydrolyzable nitrogen content is on the rise at fruit-set stage, but only changes slightly. Except for fruit-set stage, the variation tendency of soil alkali-hydrolyzable nitrogen content at other stages is roughly the same with that of soil alkali-hydrolyzable nitrogen contents in 0-20 cm depth. However, there are slight differences regarding the same treatment. Compared with 0-20 cm depth, soil alkali-hydrolyzable nitrogen contents at fruit-set stage in the control group is higher than that at fruit maturation stage while alkali-hydrolyzable nitrogen content at blossom stage under the treatment of T1 (15 kg/667 m^2) is higher than that at fruit maturation stage. When potassium fertilizer is not applied, soil alkali-hydrolyzable nitrogen content at blossom stage is the highest, when potassium fertilizer is applied (T1, T2, T3), soil alkali-hydrolyzable nitrogen content at fruit-set stage is the highest.

As shown in Fig. 1c, the variation tendency of soil alkali-hydrolyzable nitrogen content in 40-60 cm depth of jujube orchards under different potassium replying number has a major difference compared with that of soil alkali-hydrolyzable nitrogen content in 0-20 and 20-40 cm depth. The difference is the most significant at fruit maturation stage, followed by fruit-set stage. With the increase of potassium application amounts, soil alkali-hydrolyzable nitrogen content at the stage before leaf expansion decreases before rising and soil alkali-hydrolyzable nitrogen contents are the highest in the control group; soil alkali-hydrolyzable nitrogen contents at blossom stage presents a drastic variation tendency of "down-up" and is the lowest in the soil depth under the treatment of T1 (applying 30 kg/667 m^2 of potassium fertilizer); soil alkali-hydrolyzable nitrogen content at fruit-set stage rises before decreasing and is the highest under the treatment of T1 (applying 15 kg/667 m^2 of potassium fertilizer) in the soil depth; soil alkali-hydrolyzable nitrogen contents in 40-60 cm depth at fruit maturation stage decreases with the increase of potassium application amounts, shows the highest in the control group (without applying potassium fertilizer) and the lowest under the treatment of T3 (applying 45 kg/667 m^2 of potassium fertilizer). It shows that potassium fertilizer acts certain inhibitory effect on the formation and accumulation of soil alkali-hydrolyzable nitrogen at 40-60 cm depth. In the control group and under the treatment of T3 (applying 45 kg/667 m^2 of potassium fertilizer), soil alkali-hydrolyzable nitrogen content at blossom stage is the highest; under the treatment of T1 (applying 15 kg/667 m^2 of potassium fertilizer) and T2 (applying 30 kg/667 m^2 of potassium fertilizer), soil alkali-hydrolyzable nitrogen content is relatively high at fruit-set stage and relatively low at the stage before leaf expansion in the soil depth.

From Fig. 1d, it can be seen that soil alkali-hydrolyzable nitrogen content at blossom stage decreases before rising by a large margin and is relatively high under the treatment of T3 (applying 45 kg/667 m^2 of potassium fertilizer), soil alkali-hydrolyzable nitrogen content at fruit-set stage presents the variation tendency of "up-down" and is relatively high under the treatment of T2 (applying 30 kg/667 m^2 of potassium fertilizer) and relatively low under the treatment of T3 (applying 45 kg/667 m^2 of potassium fertilizer). It indicates that the potassium at a high concentration will restrain the formation and accumulation of soil alkali-hydrolyzable nitrogen in the soil depth. Soil alkali-hydrolyzable nitrogen content at fruit maturation stage takes on the variation tendency of "up-down-up" and slightly decreases under the treatment of T1 and T2. Soil alkali-hydrolyzable nitrogen content in 60-80 cm depth is relatively low at the stage and a little higher in the soil depth under the treatment of T3 (applying 45 kg/667 m^2 of potassium fertilizer). In 60-80 cm depth, soil alkali-hydrolyzable nitrogen content in the control group is relatively high at blossom stage and relatively low at fruit maturation stage. Under the treatment of T1 (applying 15 kg/667 m^2 of potassium fertilizer) and T2 (applying 30 kg/667 m^2 of potassium fertilizer), soil alkali-hydrolyzable nitrogen content is relatively high at fruit-set stage and relatively low at blossom stage. Under the treatment of T3 (application of potassium fertilizer 45 kg/667 m^2), soil alkali-hydrolyzable content is relatively high at blossom stage and relatively low at fruit-set stage.

Through conducting an analysis on the correlation between the application amount of potassium fertilizer and alkali-hydrolyzable nitrogen contents in different soil depths at different growth stages, it is found that most of them show one-knob linear relationship or power function relationship. The application amount of potassium fertilizer has a significant linear negative correlation (y = 40.662x-0.2285, -0.8769*) with soil alkali-hydrolyzable nitrogen contents in 0-20 cm depth at the stage before leaf expansion, a remarkable positive correlation ($y = 33.227x^{0.1217}$, 0.95678*) with soil alkali-hydrolyzable nitrogen contents in 20-40 cm depth at fruit-set stage and an obvious exponential negative correlation ($y = 21.132x^{-0.3092}$, -0.9835**) with soil alkali-hydrolyzable nitrogen content in 40-60 cm depth at fruit maturation stage. The reason for the result has something to do with the antagonism of ammonium ions and potassium ions as well as the differences of absorbing and accumulating nitrogen at different stages of jujubes (Table 1).

Table 1: Correlation of applying potash fertilizer number and soil hydrolyzable nitrogen content in different depth

Soil depth and growth stage	Correlation equation	Correlation coefficient
0-20 cm		
Before leaf expansion	y = 40.662x-0.2285	-0.8769*
Blossom stage	$y = 58.667x^{-0.3529}$	-0.6780
Fruit-set stage	$y = 51.75x^{0.0234}$	0.1655
Fruit maturation stage	y = -4.6536x+60.51	-0.8131
20-40 cm		
Before leaf expansion	y = 1.652x+24.108	-0.7200
Blossom stage	$y = 39.992x^{-0.3657}$	-0.7448
Fruit-set stage	$y = 33.227x^{0.1217}$	0.95678*
Fruit maturation stage	$y = 23.924x^{-0.2062}$	0.5588
40-60 cm		
Before leaf expansion	$y = 11.977x^{-0.2257}$	-0.5276
Blossom stage	$y = 23.538x^{-0.1852}$	-0.2390
Fruit-set stage	y = -2.1056x+28.84	-0.2837
Fruit maturation stage	$y = 21.132x^{-0.3092}$	-0.9835**
60-80 cm		
Before leaf expansion	$y = 13.24x^{-0.1062}$	-0.3526
Blossom stage	$y = 12.424x^{0.3043}$	-0.1581
Fruit-set stage	y = -4.6312x+31.33	-0.6535
Fruit maturation stage	$y = 18.954x^{-0.131}$	0.8615

Influence of different application amounts of potassium fertilizer on the dynamics of accumulation of total nitrogen contents for various organs of red jujube plants: From Fig. 2a, it can be seen that total nitrogen contents in roots decreases before increasing slightly and is a little higher in roots under the treatment of T3 (applying 45 kg/667 m^2 of potassium fertilizer) at the stage before leaf expansion with the increase of potassium application amounts; at blossom stage, total nitrogen content in roots decreases before increasing and is a little lower in roots under the treatment of T2 (applying 30 kg/667 m^2 of potassium fertilizer); at fruit-set stage, total nitrogen contents in roots basically stays the same at first, decreases then and rises slightly and is relatively low under the treatment of T2 (applying 30 kg/667 m^2 of potassium fertilizer); at fruit maturation stage, total nitrogen contents in roots presents the variation tendency of "down-up-down" slightly with the increase of potassium application amounts. Under the same treatment, total nitrogen contents from high to low at various stages is at the stage leaf expansion stage, blossom stage, fruit maturation stage and fruit-set stage.

From Fig. 2b, it can be found that total nitrogen contents in primary stems rises before decreasing with the increase of potassium application amounts, basically stays the same with only a slight change under the treatment of from T2 (applying 30 kg/667 m^2 of potassium fertilizer) to T3 and is a little higher under the treatment of T1 (applying 15 kg/667 m^2 of potassium fertilizer); at blossom stage, total nitrogen content in primary stems basically remains unchanged under the treatment of from CK to T_2 (applying 30 kg/667 m^2 of potassium fertilizer) and is on the decrease under the treatment of T2 (applying 30 kg/667 m^2 of potassium fertilizer) to T3 (applying 45 kg/667 m^2 of potassium fertilizer); at fruit-set stage, total nitrogen content basically stays the same with no significant changes with the increase of potassium application amounts, indicating that the application amount of potassium fertilizer has no significant influence on the dynamics of total nitrogen

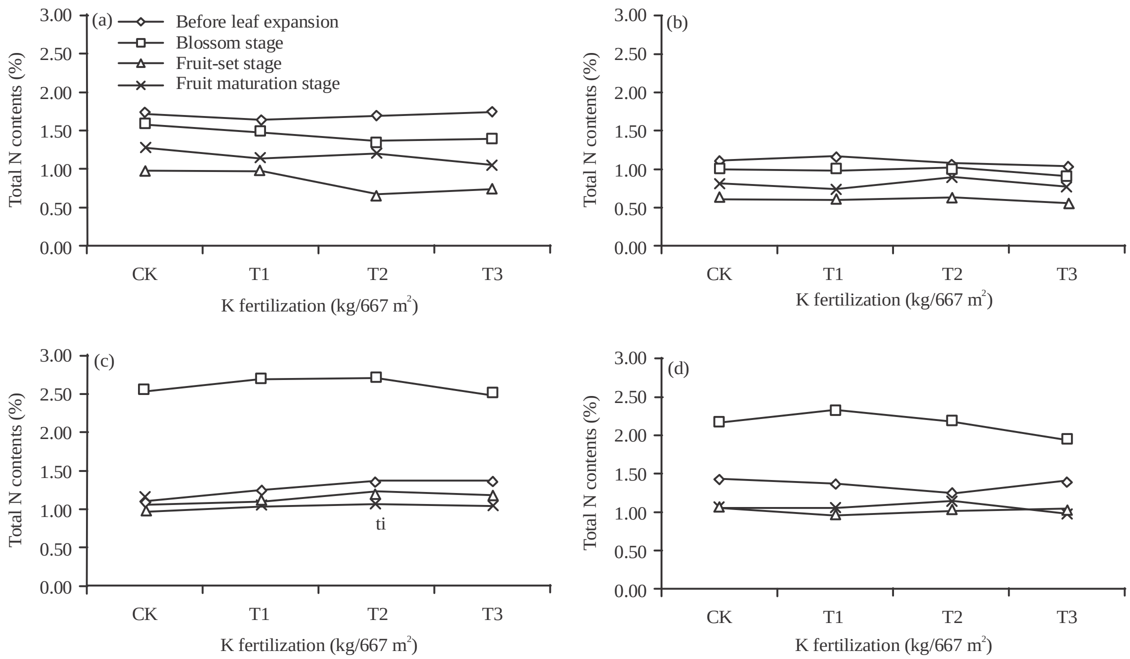

Fig. 2(a-d): Dynamics of total N content in jujube, (a) Root, (b) Primary stem, (c) Secondary branches and (d) Annual branch under different potassium replying number

content in primary stems at the stage; at fruit maturation stage, total nitrogen contents in primary stems presents the variation tendency of “down-up-down”, is a little lower in primary stems under the treatment of T1 (applying 15 kg/667 m^2 of potassium fertilizer) and a little higher in primary steams at the stage under the treatment of T2 (applying 30 kg/667 m^2 of potassium fertilizer). At various stages, total nitrogen content in primary steams from high to low is at the stage before leaf expansion, blossom stage, fruit maturation stage and fruit-set stage, which is the same with that in roots.

According to Fig. 2c, total nitrogen content in secondary branches is on the rise slightly at the stage before leaf expansion and fruit-set stage with the increase of potassium application amounts, showing that total nitrogen content in secondary branches increases with the increase of potassium application amounts at the stage before leaf expansion and fruit-set stage; at blossom stage, total nitrogen content in secondary branches slightly changes, indicating the application amount of potassium fertilizer has no significant influence on the dynamics of total nitrogen content in secondary branches at blossom stage; at fruit maturation stage, total nitrogen content in secondary branches decreases with the increase of potassium application amounts and basically stays the same under the treatment of from T1 (applying 15 kg/667 m^2 of potassium fertilizer) to T3 (applying 45 kg/667 m^2 of potassium fertilizer), showing that applying no potassium fertilizer is more beneficial to the accumulation of total nitrogen in secondary branches at fruit maturation stage. Except for the control group, total nitrogen content in secondary branches under other three treatments from high to low is at blossom stage, the stage before leaf expansion, fruit-set stage and fruit maturation stage.

Figure 2d shows total nitrogen content in annual branches decreases before increasing slightly at the stage before leaf expansion and is a little lower in annual branches at the stage under the treatment of T2 (applying 30 kg/667 m^2 of potassium fertilizer); at blossom stage, total nitrogen content in annual branches takes on the variation tendency of “up-down”, with a slight change and is a little higher in annual branches at the stage under the treatment of T1 (applying 15 kg/667 m^2 of potassium fertilizer); at fruit-set stage, total nitrogen contents in annual branches shows no significant changes with the increase of potassium application amounts, showing that the application amount of potassium fertilizer has no significance influence on the dynamics of total nitrogen content in annual branches at fruit-set stage; at fruit maturation stage, total nitrogen content in annual branches rises before decreasing and is a little higher in annual branches at the stage under the treatment of T2 (applying 30 kg/667 m^2 of potassium fertilizer). Except for the treatment of T3 (applying 45 kg/667 m^2 of potassium fertilizer), total nitrogen contents in secondary branches under other three treatments from high to low is at blossom stage, the stage before leaf expansion, fruit-set stage and fruit maturation stage.

According to Fig. 3a, total nitrogen content in leaves shows no significant changes with the increase of potassium application amounts in the whole process of growth. Total nitrogen contents in leaves is on the decrease with the advance

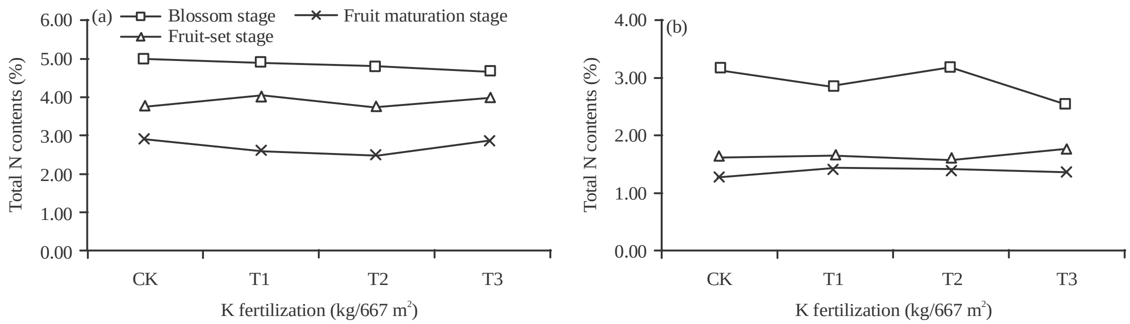

Fig. 3(a-b): Dynamics of total N contents in jujube, (a) Leaf and (b) Fruit branch under different potassium replying number

Table 2: Correlation of the total potassium contents in various organs of the whole growth period in Chinese Jujube under K fertilization

Jujube organ and growth stage	Correlation equation	Correlation coefficient
Leaf		
Blossom stage	$y = 0.9508x^{0.1870}$	0.9513*
Fruit-set stage	$y = -0.0137x+1.428$	0.2238
Fruit maturation stage	$y = 2.125x^{-0.0816}$	-0.6640
Fruit branch		
Before leaf expansion	$y = 1.1494x^{-0.2124}$	-0.3289
Blossom stage	$y = -0.0165x+2.648$	0.2301
Fruit-set stage	$y = 0.9507x^{-0.1879}$	-0. 4155
Fruit maturation stage	$y = 1.1125x^{-0.0738}$	-0.7640
Secondary branches		
Before leaf expansion	$y = 1.0494x^{0.2129}$	0.9823**
Blossom stage	$y = -0.0165x+2.647$	0.200
Fruit-set stage	$y = 0.9567x^{0.1879}$	0.9455*
Fruit maturation stage	$y = 1.1125x^{-0.0738}$	-0.7640
Annual branch		
Before leaf expansion	$y = 9.16x^{-0.1326}$	-0.3226
Blossom stage	$y = 10.281x^{0.1983}$	-0.2158
Fruit-set stage	$y = -3.622x+11.917$	-0.5352
Fruit maturation stage	$y = 3.215x^{-0.0736}$	-0.6403
Main stem		
Before leaf expansion	$y = 3.0494x^{-0.2415}$	-0.3164
Blossom stage	$y = 5.5671x^{0.1790}$	-0.3455
Fruit-set stage	$y = -0.0136x+12.65$	0.3200
Fruit maturation stage	$y = 8.16x^{-0.3426}$	-0.3526
Root		
Before leaf expansion	$y = 1.0645x^{0.2208}$	0.9673*
Blossom stage	$y = 0.9670x^{0.1889}$	0.9456*
Fruit-set stage	$y = -0.165x+4.475$	0.3087
Fruit maturation stage	$y = 1.135x^{-0.0761}$	-0.5694

of growth stage. Total nitrogen contents in leaves at blossom stage is the highest, which is about 2.5 times higher than that in leaves at fruit maturation stage.

From Fig. 3b, it can be seen that total nitrogen contents in fruit branches presents the variation tendency of "down-up-down" at blossom stage, is a little higher in fruit branches under the treatment of T2 (applying 30 kg/667 m^2 of potassium fertilizer) and a little lower under the treatment of T3 (applying 45 kg/667 m^2 of potassium fertilizer). At fruit-set stage and fruit maturation stage, total nitrogen contents in fruit branches shows no significant changes with the increase of potassium application amounts, showing that different application amounts of potassium fertilizer have no obvious influence on total nitrogen content in fruit branches at the stage. With the advance of growth stage, total nitrogen contents in fruit branches is also on the decline by a large margin, which is the same with that in leaves from blossom stage to fruit-set stage.

According to Table 2, total nitrogen contents in annual branches shows a certain but not significant correlation with the application amount of potassium fertilizer. The correlation between total nitrogen contents in other organs and the application amount of potassium fertilizer shows differences at different growth stages. At the stage before leaf expansion, the application amount of potassium fertilizer presents a significant correlation with nitrogen contents in jujube secondary branches (r = 0.9823**) and total nitrogen contents in roots (r = 0.9673*); at blossom stage, different application amounts of potassium fertilizer have a significant correlation with total nitrogen contents in roots of jujube leaves (r = 0.9513* 0.9456*); at fruit-set stage, the correlation between different application amounts of potassium fertilizer and total nitrogen contents in secondary branches at fruit-set stage reaches a significant level, which is positive (r = 0.9455*).

DISCUSSION

As a nutrient element, potassium plays an important role in the photosynthesis of plants and the synthesis of carbohydrates after being applied in soil and absorbed by plants, promotes the transport and accumulation of starch and sugar, enhances the stress and disease resistance of crops and exerts some influence on the absorption and transport of nitrogen (Bleleski and Johnson, 1972). The mutual absorption and promotion of nitrogen and potassium are not only manifested in absorption and accumulation, but also embodied in the improvement of utilization efficiency. Nitrogen content in various parts of different genotype rice treated with high potassium is lower than that treated with low potassium. Taking potassium ions as accompanying positive ions plays a part in promoting the absorption and transport of nitrate nitrogen. Through conducting studies, many scholars including, Cui *et al.* (2011) found a moderate application amount of potassium fertilizer could effectively promote the nitrogen absorption of tomato plants, while an excessive application amount of potassium fertilizer would curb the nitrogen absorption of tomato plants. Many scholars including, Chen *et al*. (2011) pointed out that flower bud differentiation stage and primary fruit stage were critical stages for jujube fruit branches to absorb nitrogen when studying the influence of fertilization on the growth, nutrition and characteristics of jujubes. As a result, an appropriate amount of nitrogen should be increased before the flower bud differentiation stage and primary fruit stage of jujubes, so as to promote the growth of jujube fruit branches and guarantee the stable and high yield of jujubes. In the relationship among the application amount of potassium fertilizer, soil fertility, plant nutrient and rice yield in a rice experiment, many scholars including, Liu *et al*. (2003) pointed out that the application amount of potassium fertilizer showed a significant negative correlation with soil alkali-hydrolyzable nitrogen contents and rapidly available phosphorus content.

According to the study, soil alkali-hydrolyzable nitrogen contents decreases with the increase of soil depth. Soil alkali-hydrolyzable nitrogen content in different soil depths is always relatively low at the stage before leaf expansion and relatively high at blossom stage or fruit-set stage. Total nitrogen content in various organs is different with the dynamics of jujube plants at different growth stages. Total nitrogen contents in primary stems and roots are the highest at the stage before leaf expansion, showing that most of nitrogen nutrition in soil is absorbed by primary stems and roots at the stage. Total nitrogen contents in secondary branches, perennial branches, annual branches, fruit branches and leaves is the highest at blossom stage. Compared with other organs, total nitrogen contents in primary stems and roots is relatively low. Total nitrogen content in leaves and fruit branches is relatively high, which indicate that most of nitrogen absorbed by jujubes from fertilizer is accumulated by a part of organs aboveground, only a little nitrogen is accumulated by a part of organs underground and the demand of leaves for nitrogen is high. Different application amounts of potassium fertilizer will curb the absorption and accumulation of total nitrogen in roots to some extend. Applying 30 kg/667 m^2 of potassium fertilizer can help fruit branches and perennial branches to absorb and accumulate total nitrogen content before fruit-set stage. The application amount of potassium fertilizer shows a significant linear negative correlation with alkali-hydrolyzable nitrogen contents in 0-20 cm depth at the stage before leaf expansion (r = -0.8769*), a remarkable positive correlation with alkali-hydrolyzable nitrogen contents in 20-40 cm depth at fruit-set stage (r = 0.95678*) and a notable exponential negative correlation with alkali-hydrolyzable nitrogen content in 40-60 cm depth at fruit maturation stage (r = -0.9835**). The application amount of potassium fertilizer presents a very significant correlation with nitrogen contents in jujube secondary branches at the stage before leaf expansion (r = 0.9823**), an obvious correlation with total nitrogen content in roots (r = 0.9673*), a prominent positive correlation with total nitrogen contents in jujube leaves and roots at blossom stage (r = 0.9513* 0.9456*) and an evident correlation with total nitrogen contents in secondary branches at fruit-set stage (r = 0.9455*).

CONCLUSION

Different application amounts of potassium fertilizer will get a consistent result for different organs of jujubes at different growth stages. Namely, a moderate application amount of potassium fertilizer can effectively promote the nitrogen absorption of jujube plants while an excessive application amount of potassium fertilizer will curb the nitrogen absorption of jujube plants.

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