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PRODUCTION AND GROWTH OF JUJUBE AS AFFECTED BY NK NUTRIENTS

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ABSTRACT
To investigate the effect of NK fertilizers on the growth and production of jujube, the mature fruit bearing jujube trees in the orchard of Sindh Agriculture University Tandojam were studied for one complete fruiting season 2006-2007. Six treatments of N-K fertilizer levels; [0N-0K (control), 0.250N-0.250K, 0.500N-0.500K, 0.750N-0.750K, 1.000N-1.000K and 1.250N-1.250K kg tree^{-1}] were used in this study. Results indicated that all the growth, fruit yield and quality characters were significantly affected by varying rates of NK nutrients. Highest N-K level (1.250-1.250 kg tree^{-1}) resulted 61.72 cm stem thickness, 11.09 m tree spread, 170.88 kg fruit yield tree^{-1}, fruit moisture 84.03%, TSS 12.46%, fruit pH 5.60 and 0.92 specific gravity; while 1.000-1.000 N-K kg tree^{-1} resulted 61.42 cm stem thickness, 10.83 m tree spread, 168.08 kg fruit yield tree^{-1}, 84.07% fruit moisture, 12.41% TSS, 5.42 fruit pH and 0.91 specific gravity. Similarly, N-K rate of 0.750-0.750 kg tree^{-1} resulted 58.38 cm stem thickness, 9.19 m tree spread, 135.33 kg fruit yield tree^{-1}, 81.96% fruit moisture, 12.22% TSS, 5.13 fruit pH and 0.88 specific gravity; while N-K level of 0.500-0.500 tree^{-1} resulted 55 cm stem thickness, 8.96 m tree spread, 100.45 kg fruit yield tree^{-1}, 81.60% fruit moisture, 11.60% TSS, 5.13 fruit pH and 0.86 specific gravity. The reducing N-K level upto 0.250-0.250 kg tree^{-1} resulted 53.13 cm stem thickness, 8.26 m tree spread, 75.39 kg fruit yield tree^{-1}, 78.50% fruit moisture, 11.50% TSS, 5.03 fruit pH and 0.84 specific gravity. However, control treatment resulted 49.62 cm stem thickness, 6.30 m tree spread, 59.69 kg fruit yield tree^{-1}, 74.57% fruit moisture, 11.07% TSS, 4.40 fruit pH and 0.80 specific gravity. The values for all the growth, yield and quality characters were simultaneously decreased with reducing quantities of N-K nutrients and least values were recorded in case of control. However, 1.00-1.00 kg N-K level proved to be an optimum level, because the differences in values for almost all the traits under study between N-K levels of 1.00-1.00 kg and 1.250-1.250 kg tree^{-1} were non-significant.

Key words: Jujube (*Ziziphus jujuba* Mill), Nitrogen and Potassium fertilizer, ber, fruit moisture, TSS

INTRODUCTION
Jujube, *Ziziphus jujuba* Mill., locally called 'ber', and belongs to the family Rhamnaceae, is an indigenous fruit of China and South Asia, produced in temperate regions such as China, India, Pakistan, Syria, Australia and Malaysia. Jujube requires a hot and dry climate. It can survive temperatures of up to 50^{o} C, and with such a tolerance for heat it is of little surprise that it does not do well when temperatures approach freezing. Jujube fruits are deciduous and can tolerate cold winters to 28 ^{o}F. They have a low chilling requirement allowing them to produce fruit in areas having mild winters. Long, hot summers are necessary to ripen good fruit crops. Pollination is done by bees and flies. In Pakistan, jujube is extensively cultivated, but thrive best under ecological conditions of Hyderabad, Khairpur, Multan, Sargodha and Lahore Divisions. Hyderabad is famous for producing quality fruit for export to Middle East. The tree is hard, drought-resistant and can thrive in poor alkaline tracts without much irrigation and care, and survive on soils where other fruit trees cannot (Khushk, 2002). It tolerates many types of soils, but prefers sandy, well-drained soils and does less well in heavy, poorly drained soil (Martinuzzo, 2006). The immature fruit

is green in color, but mahogany-colored spots appear on the skin as the fruit ripens, and the fully mature fruit is entirely brown. Shortly after becoming fully brown, the crisp fruit begins to soften and wrinkle. The fruit can be eaten after it becomes wrinkled, but most people prefer them during the 3-5 day interval between the first appearance of the brown color and the time when wrinkling begins. The crop ripens non-simultaneously, and fruit can be picked for several weeks from a single tree (Schalau, 2007).

No work has been reported on proper NPK requirements for jujube. However, it was concluded from the experiments conducted at Jujube Research Station, Tandojam that 1.0-0.5-1.0 NPK nutrients kg tree^{-1} given as ½ N + all P and K in August remaining and ½ N in December remained the optimum level for maximum jujube fruit production (JRS, 2004). Traditional manure and ash as fertilizer has been in use for jujube, but, in recent years, each tree has been given annual treatments of 10 kg FYM with 0.500 kg ammonium sulphate for every year of age up to the 5th year (Diggs, 1999). More advanced farmers utilize only commercial fertilizer (NPK) in larger amounts, twice annually, the first at the rate of about 110 kg ha^{-1} and the second at about 172 kg ha^{-1} (Morton, 1997).

The present investigation thus has been performed to examine the impact of NK nutrients on the growth, fruit production and quality of jujube under agro-ecological conditions of Tandojam.

MATERIAL AND METHODS

In order to investigate the effect of potassium (K) and nitrogen (N) on the growth and production of jujube, the study was carried out at the Jujube Orchard, Department of Horticulture, Sindh Agriculture University Tandojam during the year 2006-2007. Total 18 mature, fruit bearing jujube trees were selected which were divided into three replications and each replication has six plots to assign six treatments (NK fertilizer levels). The trees were marked for this experiment by painting the treatment numbers on their stems. The marking of the trees was done in the month of December. After marking the treatments and replications, the rings were prepared to apply inputs. All the jujube trees selected for this experiment belonged to variety Gola. Following are the treatment details regarding pruning of jujube trees:

Treatments
N-K levels= 6

T_1 0-0 kg N-K tree^{-1} (control)
T_2 0.250-0.250 kg N-K tree^{-1}
T_3 0.500-0.500 kg N-K tree^{-1}
T_4 0.750-0.750 kg N-K tree^{-1}
T_5 1.000-1.000 kg N-K tree^{-1}
T_6 1.250-1.250 kg N-K tree^{-1}

Jujube trees under experiment were supplied with necessary inputs at flowering, fruit formation and further fruit development stages. After completion of the harvesting of the jujube fruits of the previous season, the pruning was carried out on 31.03.2006. After completion of the pruning practice, the experimental trees growing already in the orchard had 25 feet distance between each tree. For nutrient management, nitrogen in the form of Urea and potash in the form of muriate of potash alongwith 40 kg of farm yard manure were applied as various split doses to each experimental tree. The effect of NK levels was investigated on the following parameters.

1. Stem thickness (cm)
2. Spread of tree (m)
3. Fruit yield (kg tree^{-1})
4. Fruit moisture content (%)
5. T.S.S. in fruit (%)
6. Fruit pH
7. Specific gravity

For recording stem thickness, a measuring tape was used and for measurement of tree spread same measuring tape was used and spread was recorded in meters. For observation on the fruit yield, different pickings were practiced on maturity of fruit and fruit on each experimental tree were individually harvested and weighed. Finally, the fruit yield for all the pickings in each tree was recorded. In case of fruit moisture, T.S.S., fruit pH and specific gravity, the randomly selected mature fruits were brought to the laboratory and after preparation of samples and passing through certain laboratory processes for each characteristic, the above parameters were determined under the guidance of research supervisor. Finally, the data so collected were subjected to statistical analysis. The analysis of variance was employed to examine the significance for each character for overall treatments, while the L.S.D. (Least Significant

Differences) test was employed to compare the treatment means, following the statistical methods suggested by Steel and Torrie (1997).

RESULTS AND DISCUSSION

The scope of potassium application alongwith nitrogen in fruit orchards is increasing consistently because of their positive results on soil fertility and fruit production. The effect of NK fertilizers on growth and fruit production of jujube is parameter-wise discussed hereunder:

Stem thickness (cm)

Stem thickness of jujube is obviously influenced by application of NK fertilizers to varied proportions, because K fertilizers work more in development of roots to provide strength to the tree. The results relating to stem thickness of jujube as affected by varied NK levels are reported in Table-1. The results of the analysis of variance illustrated that application of potassium fertilizers alongwith N at varied levels displayed significant (P<0.01) impact on stem thickness.

The results in Table-1 explicit that fertilizer application at 1.250-1.250 kg N-K tree^{-1} influenced jujube tree by improving stem thickness upto 61.72 cm, closely followed by 61.42 cm stem thickness recorded under N-K application at the rate of 1.000-1.000 kg tree^{-1}. Decreasing N-K fertilizers to 0.750-0.750 kg and 0.500-0.500 kg tree^{-1} resulted jujube trees with relatively lesser stem thickness of 58.38 and 55.00 cm, respectively; which was even reduced to 53.13 cm by lowering the N-K fertilizers to the rates of 0.250-0.250 kg tree^{-1}. However, the jujube trees with minimum stem thickness of 49.62 cm were observed in case of zero application of NK fertilizers (control). It was noted that combined application of potassium alongwith nitrogen showed positive and significant impact on stem thickness of jujube tree and each decrease or increase in NP rates exposed a simultaneous impact of stem thickness. However, impact of NK fertilizers was not so pronounced when applied beyond 0.750-0.750 kg tree^{-1}.

Spread of tree (m)

Spread of tree is mainly associated with length of branches of jujube which is evidently occurred under the impact used inputs and particularly by nutrient application. The results in relation to tree spread as affected by different NK levels are given in Table-1 which revealed that the effect of K application alongwith N on spread of jujube trees was statistically significant (P<0.05).

It is evident from the results (Table-1) that highest N-K level of 1.250-1.250 kg tree^{-1} caused significantly maximum spread of jujube tree (11.09 m), closely followed by N-K levels of 1.000-1.000 and 0.750-0.750 kg tree^{-1}, resulting average tree spread of 10.83 and 9.19 m, respectively. Reduced quantity of N-K fertilizers (0.500-0.500 kg tree^{-1}) showed a noticeable reduction in tree spread (8.96 m), while lowest N-K application of 0.250-0.250 kg tree^{-1} showed a diminishing trend with average tree spread of 8.26 m. However, the minimum spread of jujube tree (6.30 m) was recorded in case of control, where neither N and or the K were applied to the trees. It was observed that spread of jujube trees was successively improved with increasing N-K rates. However, this increase was statistically uneconomical when N-K rates increased beyond 0.750-0.750 kg tree^{-1}; because the differences between 0.750-0.750, 1.000-1.000 and 1.250-1.250 kg tree^{-1} were non-significant.

Fruit yield (kg tree^{-1})

While research is conducted for production point of view, yield per unit is always of absolute consideration. The results regarding the fruit yield tree^{-1} as affected by different N-K levels are presented in Table-1 demonstrating that the effect of N-K application on fruit yield tree^{-1} of jujube was statistically significant (P<0.01).

The results (Table-1) further indicated that the highest N-K level of 1.250-1.250 kg tree^{-1} resulted significantly maximum fruit yield tree^{-1} (170.88 kg), closely followed by N-K level of 1.000-1.000 kg tree^{-1}, resulting average fruit yield of 168.08 kg tree^{-1}. Reduction in N-K fertilizer levels to 0.750-0.750 and 0.500-0.500 kg tree^{-1} showed a substantial decrease in fruit yield tree^{-1} to 135.33 and 100.45 kg, respectively. The lowest N-K level of 0.250-0.250 kg tree^{-1} followed a declining tendency with lowering fruit yield to 75.39 kg tree^{-1}. However, the control trees, which were left untreated, performed poorly with minimizing average fruit yield of 59.69 kg tree^{-1}. The context of the results led to suggest that fruit yield tree^{-1} was substantially improved with each increment in rates of N-K fertilizers. However, application of N-K fertilizers did not prove to be economical, when their rates were increased to 1.250-1.250 kg trees^{-1}; hence, N-K level of 1.000-1.000 kg tree^{-1} considered to be an optimum level for this character.

Moisture content in fruit (%)

The data pertaining to fruit moisture content as affected by different N-K levels are reported in Table-1, suggesting the effect of N-K levels on moisture content in fruit of jujube statistically significant ($P<0.01$).

It is obvious from the results (Table-1) that the moisture content was maximum (84.07%) in fruits harvested from trees fertilized with N-K level of 1.000-1.000 kg tree^{-1}, closely followed by highest N-K level of 1.250-1.250 kg resulting average fruit moisture content of 84.03%. It was further noted that fruit moisture content noticeably decreased to 81.96 and 81.60% in fruits harvested from the trees receiving N-K fertilizers at the rates of 0.750-0.750 and 0.500-0.500 kg tree^{-1}, respectively. The moisture content showed a decline (78.50%) in fruits harvested from the trees fertilized with lowest N-K level of 0.250-0.250 kg tree^{-1}. However, the fruit moisture content was minimum (74.57%) in fruits harvested from the trees no N-K fertilizer was applied. There was a considerable variation in fruit moisture content under varying N-K levels; however, the moisture content was optimally maintained by trees receiving N-K fertilizers at 1.000-1.000 kg tree^{-1}, further increase in N-K rates did not show economic results for this parameter.

T.S.S. (%)

The results in relation to T.S.S. percentage as affected by different N-K levels are shown in Table-1. Statistically, the effect of N-K levels on T.S.S. in fruit juice of jujube was significant ($P<0.01$).

The results indicated that the T.S.S. was maximum (12.46%) in fruits harvested from trees fertilized with highest N-K level of 1.250-1.250 kg tree^{-1}, closely followed by N-K level of 1.000-1.000 and 0.750-0.750 kg tree^{-1}, where the average T.S.S. was 12.41 and 12.22 %, respectively. It was further noted that T.S.S. percentage in fruit was decreased considerably to 11.60 and 11.50% in fruits harvested from the trees receiving N-K fertilizers at the rates of 0.500-0.500 and 0.250-0.250 kg tree^{-1}, respectively. However, the minimum T.S.S. percentage (11.07%) was recorded in fruits harvested from the trees left without application of N-K fertilizers (control). It was observed that the differences in T.S.S. percentage in fruits harvested from trees fertilized with 1.250-1.250, 1.000-1.000 and 0.750-0.750 kg tree^{-1} were statistically non-significant; and similar was the circumstances for this character under 0.500-0.500, 0.250-0.250 and 0-0 kg N-K tree^{-1}.

Fruit pH

The data regarding the fruit pH of jujube as affected by different N-K levels are presented in Table-1 which shows that the fruit pH of jujube was significantly ($P<0.01$) affected by varying rates of N-K fertilizers.

It is apparent from the results (Table-1) that the fruit pH of jujube was maximum (5.60) in fruits harvested from trees fertilized with highest N-K level of 1.250-1.250 kg tree^{-1}, followed by N-K level of 1.000-1.000 and 0.750-0.750 kg tree^{-1}, where the average fruit pH was 5.42 and 5.13, respectively. It was further noted that fruit pH level in fruit was decreased considerably to 5.13 and 5.03 in fruits harvested from the trees receiving N-K fertilizers at the rates of 0.500-0.500 and 0.250-0.250 kg tree^{-1}, respectively. However, the lowest level of fruit pH (4.40) was recorded in fruits harvested from the trees left without application of N-K fertilizers (control). The results showed that increasing quantities of N-K fertilizers positively affected the fruit pH level in jujube. It was observed that the differences in pH of fruits harvested from trees fertilized with 0.750-0.750, 0.500-0.500 and 0.250-0.250 kg tree^{-1} were statistically non-significant; but highly significant when the above treatments were compared with 1.000-1.000, 1.250-1.250 kg N-K tree^{-1} and control.

Specific gravity

The results in relation to specific gravity of jujube fruit juice as affected by different N-K levels are recorded in Table-1 which suggests that the specific gravity of jujube fruit juice was significantly ($P<0.01$) influenced by varying rates of N-K fertilizers.

The results (Table-1) demonstrated that the specific gravity of juice was maximum (0.92) in fruits harvested from trees fertilized with highest N-K level of 1.250-1.250 kg tree^{-1}, followed by N-K levels of 1.000-1.000 and 0.750-0.750 kg tree^{-1}, where the average specific gravity was 0.91 and 0.88, respectively. It was further noted that specific gravity in juice was decreased considerably to 0.86 and 0.84 in fruits harvested from the trees receiving N-K fertilizers at the rates of 0.500-0.500 and 0.250-0.250 kg tree^{-1}, respectively. However, the lowest of specific gravity (0.80) was recorded in fruits harvested from the trees left without application of N-K fertilizers (control). The results showed that increasing quantities of N-K fertilizers positively affected the specific gravity in jujube fruit juice. However, differences in specific gravity either between N-K levels of 0.750-0.750 and 0.500-0.500 or 1.000-1.000 and 1.250-1.250 kg N-K tree^{-1} were statistically non-significant ($P>0.05$), while significant when compared with specific gravity under 0.250-0.250 kg N-K level or control.

DISCUSSION

The soils under orchards have become deficient in potassium, because mostly nitrogen and to some extent phosphorus was used, but use of potassium was ignored assuming that these soils are adequate in potassium. But, the experiments proved that soils have become deficient of all three major nutrients and particularly, the orchard soils are under severe deficiency of potassium too. In the present investigation, the values for all the growth, yield and quality characters were simultaneously decreased with reducing quantities of N-K nutrients and least values were recorded in case of control. However, 1.00-1.00 kg N-K level proved to be an optimum level, because the differences in values for almost all the traits under study between N-K levels of 1.00-1.00 kg and 1.250-1.250 kg tree^{-1} were non-significant (JRS, 2004). Lal and Dhaka (2003) applied K at the rate of 0, 50 and 100 kg K_2O per tree of jujube and reported that stem girth, fruit weight, total soluble solids, acidity and yield of ber were significantly affected by the application of and K. Baloch (2004) fertilized jujube trees with 1.0-0.5-1.0 NPK nutrients kg tree^{-1} alongwith well rotten FYM at rate of 60 kg plant^{-1} and reported tree spreading 8.50 meters and fruit yield of 141 kg per tree. The above results are entirely in concurrence to those obtained in the present investigation.

Table-1: Mean Values of Parameters under study of jujube tree as influenced by different NK levels

Treatments (Kg N-K tree^{-1})	Stem thickness (cm)	Spread of Tree (m)	Fruit yield (kg/tree)	Moisture content in fruit (%)	T.S.S. in fruit juice (%)	Fruit pH level	Specific gravity
T_1 (0-0) (Control)	49.62 bc	6.30 c	59.69 d	74.57 d	11.07 b	4.40 d	0.80 d
T_2 (0.250-0.250)	53.13 b	8.26 b	75.369 d	78.50 c	11.50 b	5.03 c	0.84 c
T_3 (0.500-0.500)	55.00 ab	8.96 ab	100.45 c	81.60 b	11.60 b	5.13 c	0.86 b
T_4 (0.750-0.750)	58.38 a	9.19 a	135.33 b	81.96 b	12.22 a	5.13 c	0.88 b
T_5 (1.000-1.000)	61.42 a	10.83 a	168.08 a	84.07 a	12.41 a	5.42 b	0.91 a
T_6 (1.250-1.250)	61.72 a	11.09 a	170.88 a	84.03 a	12.46 a	5.60 a	0.92 a
Statistical Analysis							
S.E.±	1.3034	0.6625	4.1596	0.3787	0.1036	0.0259	0.0043
LSD 0.05	5.477	2.78	17.48	1.591	0.4340	0.1085	0.0171
LSD 0.01	7.504	-	23.95	2.180	0.5946	0.1486	0.0235
CV%	5.65	17.92	8.61	1.15	2.14	1.24	1.22

Values followed by similar letters do not differ significantly at 0.05 probability level.

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