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# Phosphorus Fertigation and preplant Conventional Soil Application of Drip Irrigated Grapevines

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FIELD experiment was conducted for two consecutive seasons (2011 and 2012) to compare Grapevine response to conventional soil P application as triple super phosphate (TSP) and fertigation when P is applied in the form of phosphoric acid ($H_3PO_4$), ammonium polyphosphate (APP) and urea phosphate (UP). Two rates of phosphorus were used, 20 and 40 Kg $P_2O_5$/fed.

Plant and soil samples were collected and analyzed for chemical analysis. The data presented that total soluble solid (T.S.S), leaf petioles P, Zn, Fe, yield and P concentration in soil were higher with P fertigation than conventional soil P application and increased with increasing P rate. While the soil pH decreased significantly under P fertigation compared to conventional soil application.

As a source of P fertigation, the obtained revealed data presented that APP gave the highest T.S.S, leaf petioles P, Zn, Fe, yield and P concentration in soil compared with $H_3PO_4$ and UP. While UP gave the lower value of soil pH.

**Keywords**: Grapevine, Phosphorus, Fertigation, Preplant application.

On worldwide basis, grapes (*Vitis vinefera*, L) is considered the fourth crop while it ranked the first largest deciduous fruit crop. Egypt ranks on the world production scale as $14^{th}$ largest producer of grapes. Grapevines are heavily planted in the newly reclaimed areas in Egypt. Grape quality is affected by vineyard conditions; it also depends on management practices such as variety and fertilization. Grape growers in newly reclaimed areas, though, have inadequate information about suitable fertilization rates for vines especially for phosphorus. Such rates are usually added in improper wayes and rates which result in over and under supply, and which is usually associated with poor berry color, irregular and late rippning and low productivity in the following years.

Fertigation enable to control the concentration and composition of various mineral elements in the root zone since plant roots take up nutrients according to concentration gradients rather than to amount per hectar (Bravdo, 2007).

Jagdev *et al.* (2008) noticed that fertigation treatments in Thompson seedless grape increased P fertilizer use efficiency by 73.6% over the conventional methods of fertilizer application, also fertigation treatments gave higher yield of grape and the greatest nutrient use efficiency. Also, Howell and Conradie (2013) reported that daily fertigation resulted in the accumulation of P in the leaf petioles of the grapevine.

The purpose of the present research is to examine the response of drip irrigated grapevine to conventional soil P fertilizer application and fertigation when P is applied in the form of phosphoric acid, ammonium polyphosphate and urea phosphate.

## Material and Methods

A field experiment was carried out during the two successive seasons (2011-2012) on one feddan of Thompson seedless grapevines,in a vineyard farm located at El-Sadat City, Menoufiya Governorate. The vines were five years old and spaced at 1.5 m within vines and 3m between rows . The tested vines were grown in sandy soil irrigated by groundwater (EC 0.9 $dSm^{-1}$ and pH 7.60) through drip irrigation system (two lateral lines per row and emitters 50 cm. space of GR type each at 4 $Lh^{-1}$ ) . Treatments were carried out in three replicates (5 vines in each replicate) arranged in a complete randomized block design in split plot. The sources of phosphorus used in this experiment were:

a- Triple super phosphate [ ($Ca_3PO_4$) (TSP) ]
b. Phosphoric acid ($H_3PO_4$)
c. Ammonium polyphosphate [ $(NH_4)_3HP_2O_7$+ $NH_4H_2PO_4$ (APP) ]
d. Urea Phosphate [ $CO(NH_2)_2$. $H_3PO_4$ (UP) ]

The conventional application of P as triple super phosphate (TSP) was broadcast and incorporated in the top 20 cm of soil at the beging of season. For the fertigation treatments, P was applied as phosphoric acid ($H_3PO_4$ 45 % $P_2O_5$), ammonium polyphosphate (APP 52 % $P_2O_5$ and 15 % N) and urea phosphate (UP 44% $P_2O_5$ and 18 % N). Two rates of phosphorus were used, 20 and 40 Kg $P_2O_5$ / fed. Time of application of phosphorus fertigation was three times/week.

Phosphorus fertilization as fertigation started from the first of March up to $15^{th}$ of April while the rates of ammonium nitrate and potassium sulphate; 80 kg N $fed^{-1}$ and 120 kg $K_2O$ $fed^{-1}$ were applied from first of March up to $15^{th}$ of June. All treatments were once sprayed with Fe and Zn (1 gm/L). The first application at the bloom stage and the second application was after 15 days from the first application.

Table 1 presents some soil properties of the studied experimental site (0-30 cm) at the begining of season (Klute, 1986).

**TABLE 1. some soil properties of the studied experimental site**

| Particle size distribution (g/kg) | | Chemical analysis | |
|---|---|---|---|
| Clay | 47 | pH (1 : 2.5) | 8.0 |
| Silt | 5 | EC ($dS/m^{-1}$) (1:2.5) | 0.34 |
| Fine sand | 228 | $CaCO_3$ (g/kg) | 37 |
| Coarse sand | 675 | O.M (g/kg) | 0.6 |
| Texture class | Sandy | Available nutrients (mg/kg soil) | N 32<br>P 4.6<br>K 61 |

At harvesting , 5 clusters were picked randomly from 5 vines in each replicate to measure average cluster weight ,berry weight , yield = average cluster weight per vine x number of cluster per vine, TSS, expressed as Brix by using hand refractometer and chemical composition of leaf adjacent to fruit clusters was determined at bloom stage.

Representative blade sample was taken, oven dried at 70°C, ground and prepared for wet digestion using mixture of sulfuric and perchloric acids (1:1) as described by Cottenie *et al*. (1982). The digests were then subjected to measurement some nutrients (P, Fe and Zn) using procedures, according to A.O.A.C., (1990). Phosphorus concentration (%) in soil before and after fertization.

Soil samples were taken before and after fertilization in the first and last week of fertilization to measure available P concentration, according to Olsen *et al*. (1958). Additional soil samples were taken at the end of the trial in the plots underneath the dripper. Soil pH was determined according to Klute (1986).

The data were statistically analyzed according to the technique of analysis of variance (ANOVA) of randomized complete block design by Gomez and Gomez (1984).

## Results and Discussion

*Yield and yield components:*

Statistical analysis confirmed differences due to the effect of fertigation and conventional P- application to the soil (Table 2). The highest percentage of fruitfull buds and of cluster weight was recorded for P fertigation compared to P conventional application.

With regards to the source of P fertigation, the results showed that in the first and second seasons APP and UP gave higher fruitfull buds percentage at rate 40 kg $P_2O_5$ $fed^{-1}$, compared to TSP and $H_3PO_3$. Also, the results showed that, APP and UP gave the higher cluster weight at 40 kg $P_2O_5$ $fed^{-1}$, compared to the other sources of P, while there was no significant difference between APP and UP. Also, there was no significant difference between UP and $H_3PO_4$.

To asses the effect of applied P-rates , there was a significant difference between the two rates in both season. The highest percentage of fruitfull and cluster weight was recorded for vines fertilized with P rate 40 kg $P_2O_5$ fed$^{-1}$, while the lowest value was recorded with 20 kg $P_2O_5$ fed$^{-1}$. Similar results were obtained by Ahmed (1991) who studied the effect of NPK fertilization on bud behavior and he found that percentage of fruit full buds raised on Thompson seedless vines by increasing the soil application of NPK. Also, Sidhu *et al*. (2002) who reported that bunch weight increased with increasing rate of P-application.

**TABLE 2. The effect of fertigation and soil application of phosphorus on fruitfull buds and cluster weight of grape vine.**

| **Sources** | **Fruitful buds (%)** | | | **Cluster weight(kg)** | | |
|---|---|---|---|---|---|---|
| | **Season 2011** | | | | | |
| | **Rate 1** | **Rate 2** | **Mean** | **Rate 1** | **Rate 2** | **Mean** |
| TSP | 36.0 | 42.8 | 39.4 | 0.47 | 0.49 | 0.48 |
| $H_3PO_4$ | 41.0 | 46.81 | 45.91 | 0.50 | 0.52 | 0.51 |
| APP | 43.0 | 47.2 | 45.1 | 0.51 | 0.54 | 0.53 |
| UP | 45.0 | 48.1 | 46.0 | 0.53 | 0.55 | 0.54 |
| Mean | 41.3 | 46.23 | 43.60 | 0.50 | 0.53 | 0.52 |
| L.S.D 0.05 | | | | | | |
| Sources | 2.54 | | | 0.019 | | |
| Rates | 1.31 | | | 0.012 | | |
| **Season 2012** | | | | | | |
| TSP | 39.1 | 43.3 | 41.2 | 0.48 | 0.50 | 0.53 |
| $H_3PO_4$ | 43.2 | 46.3 | 44.8 | 0.51 | 0.53 | 0.52 |
| APP | 45.2 | 48.4 | 46.8 | 0.52 | 0.55 | 0.54 |
| UP | 46.1 | 49.6 | 47.9 | 0.53 | 0.56 | 0.55 |
| Mean | 43.4 | 46.9 | 45.2 | 0.51 | 0.54 | 0.54 |
| L.S.D 0.05 | | | | | | |
| Sources | 0.555 | | | 0.016 | | |
| Rates | 1.01 | | | 0.021 | | |

The results in Table 3 revealed that there is a significant difference between P ferigation and conventional P soil application on both berry weight and volume.. Also, the results showed that APP and UP produced largest berry weight and volume compared to the other P sources during the two seasons.

The results revealed that berry weight of Thompson seedless grapevine appeared heaviest with P rate of 40 kg $P_2O_5$ Fed$^{-1}$. in both seasons. Whereas, in the first season the weight and volume of 100 berries increased from 154.9 to 156.8 gm/100 berries and from 101.5 to 102.7 (cm$^3$), respectively, and in the second season from 157.2 to 160 gm/100 berries and from 103.3 to 105.5 (cm$^3$), respectively. These results could be supported by those obtained by Dhillon *et al*. (1998) and Patil *et al*. (2008),who reported the weight that of 100 berries was increased by increasing the rate of P-fertilizer application.

**TABLE 3. The effect of fertigation and soil application of phosphorus on berries weight and berries volume of grape vine.**

| Sources | 100 berries weight (gm) | | | 100 berries volume ($cm^3$) | | |
|---|---|---|---|---|---|---|
| | **Season 2011** | | | | | |
| | **Rate 1** | **Rate 2** | **Mean** | **Rate 1** | **Rate 2** | **Mean** |
| TSP | 147 | 150 | 148.5 | 97 | 99 | 98 |
| $H_3PO_4$ | 153 | 156 | 154.5 | 101.7 | 102.3 | 102 |
| APP | 159.7 | 160 | 159.8 | 103 | 104.3 | 103.7 |
| UP | 159.7 | 161.3 | 160.5 | 104.3 | 105 | 104.7 |
| Mean | 154.9 | 156.8 | 155.8 | 101.5 | 102.7 | 102.1 |
| L.S.D 0.05 | | | | | | |
| Sources | 1.34 | | | 1.36 | | |
| Rates | 1.25 | | | 0.36 | | |
| **Season 2012** | | | | | | |
| TSP | 150.0 | 153 | 151.5 | 98 | 102 | 100 |
| $H_3PO_4$ | 156.5 | 160 | 158.3 | 104 | 106 | 105 |
| APP | 161.2 | 163.1 | 162.2 | 105.3 | 107 | 106.2 |
| UP | 160.9 | 163.9 | 162.9 | 106 | 107.1 | 106.6 |
| Mean | 157.2 | 160 | 158.7 | 103.3 | 105.5 | 104.5 |
| L.S.D 0.05 | | | | | | |
| Sources | 2.99 | | | 1.76 | | |
| Rates | 1.43 | | | 1.26 | | |

Also, these results are in conformity, with the findings of Sidhu *et al*., (2002) who reported that increasing P rate caused a significant increase in the volume of 100 berries in grape vine (vitis viniferal).

The results presented in Table 4 indicate that fertigation is superior when compared to the conventional soil application of triple super phosphate. Higher yield was obtained by fertigation technique. In this way, with every irrigation the fertilizer is placed in the soil volume in which roots are more active (Papadoulos, 1995).

As a-source of P fertigation, UP and APP gave the highest yield compared with $H_3PO_3$ and TSP (7.52 and 7.06 ) ton/fed,respectively,in the first season and in the second season (7.72 and 7.34ton/fed),respectively. This can be explained by the double acidification effect of UP. These results are in accordance to those obtained by Salem *et al*. (2004).

With regard to the application rate of $P_2O_5$ data revealed that 40 kg $P_2O_5$ $fed^{-1}$ increased yield significantly than 20 kg $P_2O_5$ $fed^{-1}$ in both seasons. results are in agreement with the findings obtained by Rakicevic *et al*., (2007).

*T.S.S. of grape vine*

The data presented in Fig. 1&2 indicated that the highest average of total soluble solid in both seasons was registered with fertigation as compared to the soil application of TSP.

**Table (4): The effect of fertigation and soil application of phosphorus on yield of grape vine.**

| Sources | Yield (kg/vine) | | | Yield (Ton/fed) | | |
|---|---|---|---|---|---|---|
| | Season 2011 | | | | | |
| | **Rate 1** | **Rate 2** | **Mean** | **Rate 1** | **Rate 2** | **Mean** |
| TSP | 7.28 | 8.40 | 7.84 | 6.55 | 7.56 | 7.06 |
| $H_3PO_4$ | 7.76 | 8.95 | 8.36 | 6.98 | 8.06 | 7.52 |
| APP | 8.08 | 9.32 | 8.70 | 7.27 | 8.39 | 7.83 |
| UP | 8.31 | 9.53 | 8.83 | 7.48 | 8.58 | 8.03 |
| Mean | 7.86 | 9.05 | 8.43 | 7.07 | 8.15 | 7.61 |
| L.S.D 0.05 | | | | | | |
| Sources | 0.316 | | | 0.052 | | |
| Rates | 0.357 | | | 0.318 | | |
| Season 2012 | | | | | | |
| TSP | 7.58 | 8.71 | 8.15 | 6.82 | 7.84 | 7.34 |
| $H_3PO_4$ | 7.99 | 9.15 | 8.57 | 7.19 | 8.24 | 7.72 |
| APP | 8.34 | 9.55 | 8.95 | 7.50 | 8.60 | 8.05 |
| UP | 8.59 | 9.89 | 9.22 | 7.73 | 8.90 | 8.32 |
| Mean | 8.13 | 9.41 | 8.72 | 7.31 | 8.40 | 7.86 |
| L.S.D 0.05 | | | | | | |
| Sources | 0.445 | | | 0.399 | | |
| Rates | 0.298 | | | 0.267 | | |

The data also indicated APP gives the best measurable T.S.S, followed by UP, MAP and $H_3PO_4$ in the two growing seasons. Brito *et al*. (2000) observed that the least T.S.S was observed with $H_3PO_4$ treatment.

The data showed that the application rate of 40 kg $P_2O_5$ $fed^{-1}$ was better than 20 kg $P_2O_5$ $fed^{-1}$ in all treatments. Similar results were obtained by Salem *et al*. (2004) and Patil *et al*. (2008) who reported that raising P rate improved T.S.S in Thompson seedless grapevine.

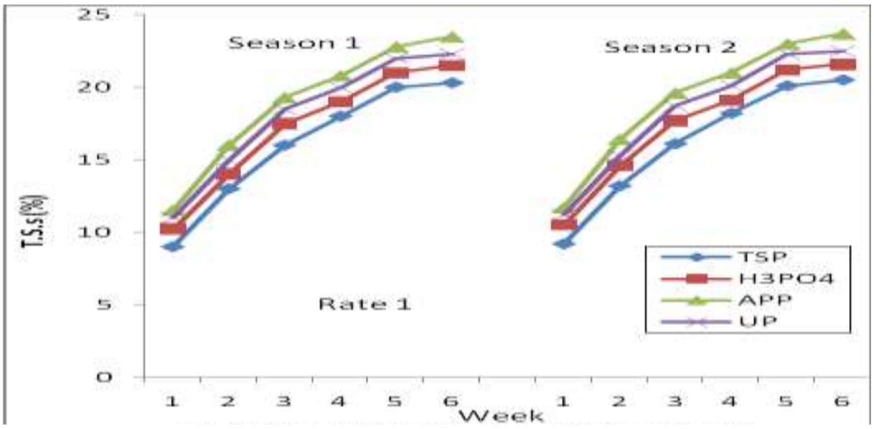


**Fig 1. Effect of fertigation and soil application of phosphorus on T.S.S (%) of grapevine**

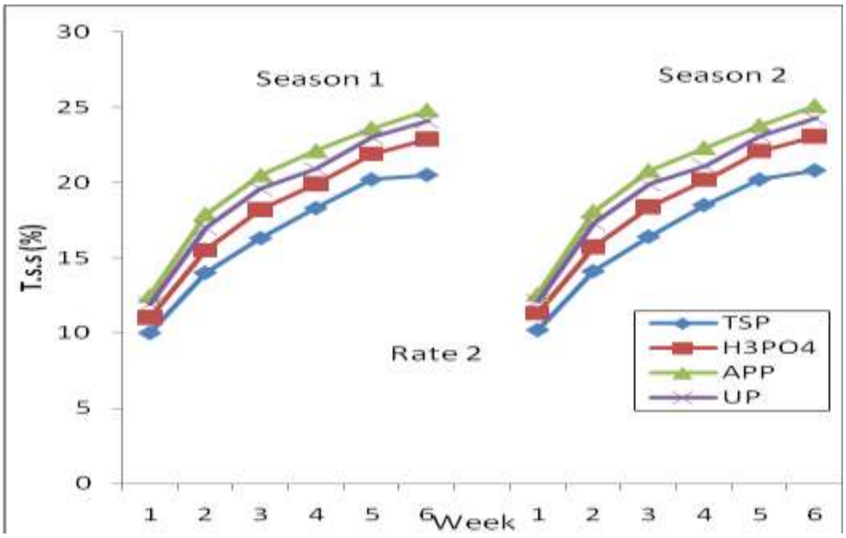


**Fig 2. Effect of fertigation and soil application of phosphorus on T.S.S (%) of grapevine**

*Phosphorus, Zn and Fe leaf petioles:*

Data in Table 5 revealed that petiole P- concentration showed a significant difference between P fertigation and soil application by TSP in both seasons. APP and UP gave the highest values. These results were in agreement with Hagin *et al*., (2002) who reported a continuous P supply through fertigation techn que, may enhance P uptake later in the season and fertigation may creat a more favourable soil moisture condition that improves P mobility and availability.

Mohammed *et al*. (2004) revealed that in both seasons, phosphorus fertilizers use efficiency was higher with P fertigation than with conventional soil application.

Also, the petiol Zn and Fe concentrations were relatively higher under APP applications compared with other sources (Table 5). This result may be attributed to sequester Fe and Zn ions by the two adjacent hydroxyl group in various polyphosphate species , which increase their availability.

The results also indicated that P, Zn and Fe concentration responded to increased phosphorus level from 20 to 40 kg $P_2O_5$/fed. This increase in the micronutrients concentration is similar to the findings of Dhillon *et al*. (1998).

*Phosphorus concentration in soil*

The available soil P concentration after fertilization significantly increased with TSP compared to P fertigation in the first week (Table 6). While, in the last week, the available soil P concentration significantly increased under P fertigation compared to the conventional application.

**TABLE 5. The effect of fertigation and soil application of phosphorus on leaf petioles P, Zn and Fe concentrations of grape vine**

| Sources | P (%) | | | Zn (mg/kg) | | | Fe (mg/kg) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Season 2011 | | | | | | | | |
| | Rate 1 | Rate 2 | Mean | Rate 1 | Rate 2 | Mean | Rate 1 | Rate 2 | Mean |
| TSP | 0.22 | 0.24 | 0.23 | 28.1 | 30.3 | 29.2 | 122 | 125 | 123.5 |
| $H_3PO_4$ | 0.26 | 0.29 | 0.28 | 28.5 | 30.9 | 29.70 | 124 | 128 | 126 |
| APP | 0.28 | 0.30 | 0.29 | 29.3 | 31.1 | 30.2 | 125 | 129 | 127 |
| UP | 0.28 | 0.29 | 0.29 | 29.1 | 31.0 | 30.1 | 125 | 127 | 126 |
| Mean | 0.26 | 0.28 | 0.27 | 28.8 | 30.8 | 29.8 | 124 | 127.3 | 125.6 |
| L.S.D 0.05 | | | | | | | | | |
| Sources | 0.013 | | | 0.843 | | | 3.46 | | |
| Rates | 0.018 | | | 1.31 | | | 2.70 | | |
| Season 2012 | | | | | | | | | |
| TSP | 0.24 | 0.27 | 0.26 | 29.0 | 31 | 30.0 | 123 | 126 | 124.5 |
| $H_3PO_4$ | 0.26 | 0.29 | 0.28 | 29.4 | 31.7 | 30.6 | 124 | 128 | 126 |
| APP | 0.29 | 0.32 | 0.31 | 29.6 | 31.9 | 30.8 | 126 | 129 | 127.5 |
| UP | 0.28 | 0.30 | 0.29 | 29.5 | 31.7 | 30.6 | 125 | 128 | 126.5 |
| Mean | 0.27 | 0.30 | 0.29 | 29.4 | 31.6 | 30.7 | 124.5 | 127.8 | 126.1 |
| L.S.D 0.05 | | | | | | | | | |
| Sources | 0.024 | | | 0.681 | | | 1.80 | | |
| Rates | 0.028 | | | 0.652 | | | 1.08 | | |

**TABLE 6. Phosphorus concentration (mg/kg soil) in soil after the first and the last week of fertilization.**

| Sources | After First week | | | After Last week | | |
|---|---|---|---|---|---|---|
| | Season 2011 | | | | | |
| | Rate 1 | Rate 2 | Mean | Rate 1 | Rate 2 | Mean |
| TSP | 9.12 | 11.31 | 10.26 | 11.30 | 12.87 | 12.09 |
| $H_3PO_4$ | 8.18 | 10.33 | 9.26 | 11.96 | 13.65 | 12.81 |
| APP | 8.40 | 10.45 | 9.42 | 11.93 | 13.96 | 12.95 |
| UP | 8.42 | 10.41 | 9.42 | 11.83 | 13.96 | 12.90 |
| Mean | 8.53 | 10.63 | 9.59 | 11.76 | 13.61 | 12.69 |
| L.S.D 0.05 | | | | | | |
| Sources | 0.125 | | | 0.097 | | |
| Rates | 0.151 | | | 0.230 | | |
| Season 2012 | | | | | | |
| TSP | 9.25 | 11.54 | 10.40 | 12.26 | 13.48 | 12.87 |
| $H_3PO_4$ | 8.38 | 10.61 | 9.50 | 12.86 | 14.33 | 13.60 |
| APP | 8.57 | 10.63 | 9.60 | 12.91 | 14.54 | 13.73 |
| UP | 8.45 | 10.55 | 9.5 | 12.82 | 14.61 | 13.72 |
| Mean | 8.66 | 10.83 | 9.75 | 12.71 | 14.24 | 13.48 |
| L.S.D 0.05 | | | | | | |
| Sources | 0.236 | | | 0.212 | | |
| Rates | 0.290 | | | 0.384 | | |

These results were in agreement with Hagin and Tucker (1982) who reported that preplant conventional soil application of P has the advantage of providing the initial high P concentration in the soil solution. The data illustrated that there was insignificant difference between APP and UP in the first and the last week in both seasons. The soil P concentration after fertilization significantly increased with increasing P rate from 20 to 40 kg $P_2O_5$ $Fed^{-1}$. This attribution is in agreement with Mohammed *et al*. (2004).

*pH of Soil*

The data presented in Table 7 indicated in both seasons, the soil pH under drippers decreased significantly under P fertigation compared to conventional application. This acidification was confirmed by earlier results of Treder (2005) and Howell & Conradie (2012).

The data showed also that UP gave lower value of soil pH compared with $H_3PO_4$ and APP,which is confirmed by Papadopoulos, (2000).

**TABLE 7. The effect of fertigation and soil application of phosphorus on soil pH after the last week fertilization.**

| **Sources** | **pH** | | | |
|---|---|---|---|---|
| | **Season 2011** | | **Season 2012** | |
| | **Rate 1** | **Rate 2** | **Rate 1** | **Rate 2** |
| TSP | 8.18 | 8.13 | 8.16 | 8.11 |
| $H_3PO_4$ | 8.09 | 8.02 | 8.06 | 8.01 |
| APP | 8.06 | 8.00 | 8.05 | 7.97 |
| UP | 8.03 | 7.96 | 8.01 | 7.93 |
| Mean | 8.09 | 8.03 | 8.07 | 8.01 |
| L.S.D 0.05 | | | | |
| Sources | 0.018 | | 0.025 | |
| Rates | 0.006 | | 0.016 | |

Urea under drip irrigation, urea phosphate is rapidly hydrolysed in the soil to ammonium and then oxidized to nitrate.

As regards to P rates, the data showed that the soil pH significantly decreased at the highest P fertilization rate which is in agreement with Mohammad *et al*., (2004).

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## اضافة الفوسفور بالرى التسميدى والاضافة التقليدية قبل الزراعة تحت نظام الرى بالتنقيط للعنب

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أقيمت تجربة حقلية لمدة موسمين متعاقبين (2011-2012) وذلك لمقارنة استجابة العنب لاضافة الفوسفور بالطريقة التقليدية فى صورة سوبر فوسفات مكرر (TSP) واضافته بالرى التسميدى . وتم اضافة الفوسفور فى ماء الرى فى صورة حامض الفوسفوريك و بولى فوسفات الامونيوم ( APP) واليوريا فوسفات ( UP ) وذلك بمعدلين من الفوسفور هما(40،20) كجم $P_2O_5$ / فدان .

وتم أخذ عينات نباتية وعينات من التربة وذلك لتحليلها . وأوضحت النتائج أن كلا من المواد الصلبة الكلية (TSS) الذائبة وتركيز الفوسفوروالزنك والحديدفى كل من الأوراق والمحصول. وتركيز الفوسفور فى التربة كان أعلى فى حالة الرى التسميدى مقارنة بالاضافة التقليدية . كما أنها زادت بزيادة معدلات التسميد الفوسفاتى . بينما انخفض رقم حموضة التربة انخفاضا معنويا فى حالة الرى التسميدى وذلك مقارنة بالاضافة التقليدية .

وبمقارنة المصادر المختلفة للفوسفور ، وجد أن المعاملة ب ( APP ) أعطى أعلى تركيز من المواد الصلبة الكلية (TSS ) وتركيز الفوسفور والزنك و الحديد في الاوراق وكذلك المحصول وتركيز الفوسفور فى التربة مقارنة بحامض الفوسفوريك واليوريا فوسفات ،بينما أعطى ( UP)أقل قيم في رقم حموضة التربة .