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# Impact of fertigation on fruit yield and quality of plum (*Prunus domestica*)

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**ABSTRACT**

Plum is an important stone fruit of Pakistan. The productivity of plum orchards in Pakistan is very low, particularly owing to the unbalanced and untimely application of fertilizer and irrigation by the farmers. Fertigation is a technique in which dissolved fertilizers are used for crops together with an irrigation system. Combined application of nutrients and water with an efficient irrigation system can result in the maximum possible yield and quality of plants. A two-year field experiment in Peshawar, Pakistan was conducted during 2018-2020 to evaluate the effect of fertigation of different rates of nitrogen (N), phosphorus (P), and potassium (K) fertilizers on yield and quality of plum. Fruit-bearing plum orchards of uniform age and size were selected. The treatments included T1 (control), T2 (NPK @ 360-250-360 g tree$^{-1}$ applied as broadcast), T3 (NPK @ 360-250-360 g tree$^{-1}$ applied as fertigation), T4 (270-187-270 g tree$^{-1}$ applied as fertigation) and T5 (NPK @ 180-125-180 g tree$^{-1}$ applied as fertigation). All the fertilizers were applied to the periphery of the plum tree canopy. The yield and fruit concentration of N, P, and K were significantly ($P<0.05$) improved in the treatments where nutrients were applied as fertigation as compared to those where fertilizers were applied as broadcast. Plum fruit yield was recorded as maximum (90.1 kg plant$^{-1}$) when NPK @ 180-125-180 g tree$^{-1}$ was applied as fertigation. Similarly, maximum N (0.56%), P (0.19%), and K (1.53%) concentrations as well as the highest value cost ratio (101.3) were obtained by the application of NPK @ 180-125-180 g tree$^{-1}$ as fertigation.

**Keywords**: Fertilizer management, Nitrogen, Phosphorus, Plum, Potassium.

## 1. Introduction

Plum (*Prunus domestica*), one of the major stone fruits of Pakistan, is a source of essential compounds that may influence human health and prevent many diseases from occurring (Stacewicz *et al*., 2001). It is also a vital source of many vitamins and minerals (Gregory, 1993). Plum is widely grown in various regions of Pakistan, especially in Peshawar, Charsadda, Nowshera, Mardan, and Swat districts of Khyber Pakhtunkhwa (KP). The soils of KP are deficient in organic matter and essential nutrients including nitrogen, phosphorus, and zinc. This deficiency is a major factor in low fruit yields and poor quality (Shah *et al*., 2019). To overcome the nutrient deficiency issue and enhance plum orchard productivity, farmers need to apply costly inorganic fertilizers. Moreover, scarce water resources in the province do not permit to apply irrigation in unplanned manner. Both the injudicious fertilization and traditional irrigation practices by the farmers reduce water and fertilizer use efficiency and shorten the productive life of fruit trees, which in turn results in decreased orchard yield (Ahmad, 2010). The situation needs to devise economical approaches for the judicious and timely application of required farm inputs (fertilizer and water) without compromising the orchard productivity. This could be achieved by optimizing the fertilizer and water application to the plum orchard through fertigation, a technique of applying plant nutrients via an irrigation system.

Fertilizers applied by the fertigation method are readily absorbed by plants and reduce nutrient loss due to various soil chemistry and environmental conditions (Kabirigi *et al.,* 2017). It has been reported by several scientists that fertilizers applied through systems showed more efficiency as compared to those hand sprayed on the soil surface (Kishore *et al*., 2006; Sandal and Kapoor, 2015). Moreover, it makes moisture available and facilitates the utilization of supplied nutrients by plants (Singh *et al*., 2005). Fertigation provides both water and essential nutrients directly to the active root zone of growing plants through irrigation systems, minimizes nutrient loss and increases fruit yield. Fertigation techniques can promote the efficient use of natural resources, improve fruit quality and yield per unit area, and orchard life, and reduce pollution (Singh *et al*., 2005). There is limited information on the effect of the fertigation of NPK fertilizers on plum. Keeping in view the importance of fertigation in orchard productivity, experiments were conducted with the aim of evaluating

**Table 1.** Selected properties of the soil used in the experiment

| Properties | Units | Status | Reference Method |
|---|---|---|---|
| Texture | --- | Clay loam | Koehler *et al.*, 1984 |
| pH | --- | 7.5 | Mclean, 1982 |
| Electrical conductivity | $dSm^{-1}$ | 0.87 | Rhoades and Miyamoto, 1990 |
| Organic matter | % | 0.9 | Nelson and Sommer, 1982 |
| Total N | % | 0.04 | Bremmer and Mulvaney, 1982 |
| Available Phosphorus | mg $kg^{-1}$ | 8 | Soltanpour and Schwab, 1977 |
| Available Potassium | mg $kg^{-1}$ | 250 | Soltanpour and Schwab, 1977 |
| Zinc | mg $kg^{-1}$ | 1 | Soltanpour and Schwab, 1977 |

**Table 2.** Details of treatments applied

| Treatments | Fertilizer Dose | Application Schedule |
|---|---|---|
| T1 | Control (No added fertilizer) | - |
| T2 | NPK @ 360-250-360 g $tree^{-1}$ applied as broadcast | Two splits<br>1. After fruit picking (July/August)<br>2. Before bud sprout (January/February) |
| T3 | NPK @ 360-250-360 g $tree^{-1}$ applied as fertigation | Three splits<br>1. 1st week of December<br>2. 1st week of March<br>3. 1st week of May |
| T4 | NPK @ 270-187-270 g $tree^{-1}$ applied as fertigation | |
| T5 | NPK @ 180-125-180 g $tree^{-1}$ applied as fertigation | |

the effect of fertigation of NPK fertilizers on plum yield and quality.

## 2. Materials and Methods

The current study was carried out at the experimental farm of NIFA, Peshawar during 2018-2020. The investigation site represents warm and humid in summer and cold in winter in the north-west of Pakistan. Before starting the experiment, soil samples were taken up to 15 cm depth and were subsequently analyzed for various physico-chemical characteristics. The selected soil properties are given in Table 1.

Ten-year-old plum trees (cultivar Fazli Manani) having uniform size, vigor, and age were selected. Five treatments were applied (Table 2), each one in triplicate. The experiment was carried out using randomized complete block design.

Standard cultural practices were applied to the experimental trees. Plum fruit samples were collected, washed, oven-dried, ground, and analyzed for N, P, and K contents. Nitrogen in plum fruit was determined using the procedure developed by Bremmer and Mulvaney (1982), while phosphorus and potassium in plum fruit were assessed following the method developed by Benton *et al*. (1991).

### 2.1. Statistical analysis

The data collected from the experimental treatments were statistically analyzed using RCB design. According to Steel and Torrie (1980), the means of data for different treatments were compared using the LSD test.

## 3. Results and Discussion

### 3.1. Plum fruit yield

Two years' average data revealed a significant effect of fertilizer applied through fertigation on fruit yield (Table 3). Statistically significant yield in all the fertigation treatments over control and non-fertigation treatment (basal application), reflects the positive effects of fertigation on plum yield. Amongst the various fertigation treatments, NPK @ 180-125-180 g $tree^{-1}$ applied as fertigation in three splits exhibited the best performance in terms of fruit yield (90.11 kg $plant^{-1}$) which was at par with NPK @ 270-187-270 g $tree^{-1}$ applied as fertigation (86.78 kg $plant^{-1}$). High yield in the said treatment may be attributed to the flexibility provided by fertigation to synchronize nutrient supply with plant demand (Neilsen *et al*., 2001). The lowest yield of 40.22 kg $plant^{-1}$ was observed in control. Suman and Raina (2014) also observed yield enhancement in

**Table 3.** Effect of fertigation applied nutrients on the yield of plum fruit

| Treatments | 1st Year Yield (kg plant$^{-1}$) | 2nd Year Yield (kg plant$^{-1}$) | Average Yield (kg plant$^{-1}$) | Increase over NPK applied as broadcast (%) |
|---|---|---|---|---|
| T1 | 35.77 f | 44.67 ef | 40.22 d | - |
| T2 | 49.08 e | 87.00 b | 68.04 c | - |
| T3 | 64.63 d | 96.00 ab | 80.32 b | 18.04 |
| T4 | 72.55 cd | 101.00 a | 86.78 ab | 27.53 |
| T5 | 76.88 c | 103.33 a | 90.11 a | 33.41 |
| Year wise Mean | 59.78 b | 86.40 a | - | - |

Within each column, means with different letter(s) are significantly different according to the LSD test at 0.05 level of probability

**Table 4.** Effect of fertigation applied nutrients on NPK concentration of Plum fruit

| Treatments | Nitrogen (%) | | | Phosphorus (%) | | | Potassium (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Year I | Year II | Average | Year I | Year II | Average | Year I | Year II | Average |
| T1 | 0.36 ef | 0.28 f | 0.32 b | 0.17 bcd | 0.12 f | 0.15 d | 1.33 cde | 1.13 de | 1.23 b |
| T2 | 0.66 ab | 0.43 de | 0.54 a | 0.20 a | 0.13 ef | 0.17 ab | 1.50 abc | 1.03 e | 1.27 b |
| T3 | 0.67 a | 0.49 cd | 0.58 a | 0.18 abcd | 0.15 de | 0.17 bc | 1.65 ab | 1.10 e | 1.75 ab |
| T4 | 0.57bc | 0.48 cd | 0.52 a | 0.16 cde | 0.14 ef | 0.15 cd | 1.43 bcd | 1.53 abc | 1.48 a |
| T5 | 0.62 ab | 0.51 cd | 0.56 a | 0.19 ab | 0.18 abc | 0.19 a | 1.80 a | 1.26 cde | 1.53 a |
| Year wise Mean | 0.576 a | 0.44 b | - | 0.18 a | 0.14 b | - | 1.54 a | 1.21 b | - |

Within each column, means with different letter(s) are significantly different according to the LSD test at 0.05 level of probability

apple crop due to fertigation. In comparison to conventional fertilizer application, fertigation results in enhanced nutrients & water management and has a positive impact on the physical and yield attributes of the fruit. The uniform application of nutrients in the active root zone area of the tree enhances nutrient uptake that may contribute to the synthesis of more metabolites as well as their translocation, ultimately resulting in improved weight, size and volume of fruits (Neilsen *et al*., 2007)

Percent increase over soil applied NPK can be a good indicator for evaluating the performance of fertigation treatment, as it quantifies fruit yield over recommended fertilizer treatment (NPK @ 360-250-360 g tree$^{-1}$). Regarding the percent increase, the results suggested the superiority of three fertigation treatments *viz.* T5 (NPK @ 180-125-180 g tree$^{-1}$), T4 (NPK @ 270-187-270 g tree$^{-1}$) and T3 (NPK @ 360-250-360 g tree$^{-1}$) over soil applied treatment i.e. T2 (NPK @ 360-250-360 g tree$^{-1}$) with values of 33, 27 and 18%, respectively.

### 3.2. Plum fruit quality

NPK concentration of plum fruit (Table 4) as influenced by fertigation-applied nutrients showed that nitrogen in plum fruit ranged from 0.32% to 0.58%. Maximum nitrogen content (0.58%) was found in T3 (NPK @ 360-250-360 g tree$^{-1}$ applied as fertigation) while minimum nitrogen content of 0.32% was recorded in the control treatment. The increased nitrogen concentrations were recorded in all the treatments where nitrogen was applied. Phosphorus (P) content in the fruit flesh of plum ranged from 0.15% to 0.19%, maximum P content was obtained in treatment T5 where NPK (180-125-180 g tree$^{-1}$) was applied through fertigation. The highest potassium 1.53% was found with T5 (NPK @ 180-125-180 g tree$^{-1}$ applied as fertigation) followed by T4 i.e. NPK @ 270-187-270 g tree$^{-1}$ applied as fertigation (1.48%), while minimum K concentration was obtained in control. Application of NPK through fertigation also proved effective on overall vegetative growth, leaf nutrient content of apple plants, and soil nutrient status

**Table 5.** Value-Cost Ratio (VCR) of the nutrients applied through fertigation

| Treatments | Fertilizer Cost (Rs.) | Total Yield (kg) | Yield Price (Rs.) | Benefit over control (Rs.) | *VCR |
|---|---|---|---|---|---|
| T1 | - | 40.12 | 4012 | - | - |
| T2 | 98.66 | 68.04 | 6814 | 2802 | 28.38 |
| T3 | 98.66 | 80.32 | 8032 | 4020 | 40.74 |
| T4 | 74.00 | 86.77 | 8677 | 4665 | 63.04 |
| T5 | 49.33 | 90.11 | 9011 | 4999 | 101.34 |

*VCR was calculated based on prevailing rates in Pakistani Rupee (Rs.) as under:

Nutrients rates (Rs. / kg): N = 78.26
$P_2O_5$ = 166.66
$K_2O$ = 80

Plum rate (Rs. / kg): 100

minimizing the fertilizer application dose and enhancing the fertilizer use efficiency. Nitrogen through fertigation reduces nitrogen losses in the soil tree system by ammonia volatilization and nitrate leaching (Smith, 2001). High N concentration due to fertigation can be due to the timely supply of this nutrient to the rooting zone to coincide with the period of rapid canopy development (Neilsen and Neilsen, 2005) and thus avoid excess nutrient application. P and K mobility is also enhanced by fertigation, which increases the potential for the timely application of such nutrients in the root zone (Neilson and Neilson, 2005). Porro *et al*. (2012) also observed the impact of fertigation on leaf and fruit nutrient concentrations.

### 3.3. Value-Cost Ratio (VCR)

Value-Cost Ratio (VCR) was significantly affected by fertigation (Table 5). Treatment 5 (NPK @ 180-125-180 g $tree^{-1}$ applied as fertigation) obtained maximum value cost ratio of 101.34 as compared to soil applied NPK @ 360-250-360 g $tree^{-1}$ with value of 28.38. Under fertigation, all the treatments perform better than the soil application. The findings are in line with those of Agrawal and Agrawal (2007) who reported that maximum VCR for pomegranate was found when 60% water was applied through drip and minimum in control. Likewise, Singh *et al*. (2007) reported the maximum VCR for guava under drip irrigation and the lowest under ring basin application. It was evident that fertilizer application through fertigation is more beneficial as compared to the broadcast method.

## 4. Conclusions

Maximum yield enhancement along with good nutrient saving was observed when NPK was applied @ 180-125-180 g $tree^{-1}$ (50% of recommended fertilizer) through fertigation. Hence, 50% of the nutrients from the recommended prevailing practice could be saved along with an increase in fruit yield. It can be concluded that fertigation offers a good potential to save nutrients as well as to enhance yield by precise and timely delivery of nutrients to the root zone of plum fruit trees. Fertigation in plum needs to be encouraged to get higher returns along with fertilizer input saving.

## References

Agrawal, N., & Agrawal, S. (2007). Effect of different levels of drip irrigation on the growth and yield of pomegranate under Chhattisgarh region. *Orissa. Journal of Horticulture*, *35*(1), 38-46.

Ahmad, N. (2010). Fertilizer scenario in Pakistan policies and development. In *Proceedings of Conference Agricultural and Fertilizer Use* (pp. 15-16).

Benton, J. Jr., Wolf, B., & Mills, H. A. (1991). Plant Analysis Hand Book. A practical sampling, preparation, analysis and interpretation guide. *Micro-Macro Publishing: Atlanta, GA*.

Bremmer, J. M., & Mulvaney, C.S. (1982). Nitrogen Total. *AL Page et al*, 595-642.

Gregory III, J. F. (1993). Ascorbic acid bioavailability in foods and supplements. *Nutrition Reviews*, *51*(10), 301-303.

Kabirigi, M., Prakash, S. O., Prescella, B. V., Niamwiza, C., Quintin, S. P., Mwamjengwa, I. A., ... & Zhang, C. (2017). Fertigation for environmentally friendly fertilizers application: Constraints and opportunities for its application in developing countries. *Agricultural Sciences*, *8*(04), 292.

Kishore, D. K., Pramanick, K. K., Sharma, K. S. & Singh, R. (2006). *Temperate Horticulture: Current Scenario*. New India Publication Agency, New Delhi, pp. 209-216

Koehler, F. E., Moudre, C. D., & McNeal, B. L. (1984). Laboratory manual for soil fertility. *Washington State University Pulman, USA*.

McLean, E. O. (1982). Soil pH and lime requirement. *Methods of soil analysis: Part 2 Chemical and microbiological properties*, *9*, 199-224.

Neilsen, G., Kappel, F., & Neilsen, D. (2007). Fertigation and crop load affect yield, nutrition, and fruit quality of 'Lapins' sweet cherry on Gisela 5 rootstock. *HortScience*, *42*(6), 1456-1462.

Neilsen, D., & Neilsen, G. (2005). Fertigation of deciduous fruit trees: apple and sweet cherry. *Fertigation Proceedings: Selected papers presented at the joint*, *20*, 76.

Neilsen, D., Millard, P., Herbert, L. C., Neilsen, G. H., Hogue, E. J., Parchomchuk, P., & Zebarth, B. J. (2001). Remobilization and uptake of N by newly planted apple (Malus domestica) trees in response to irrigation method and timing of N application. *Tree Physiology*, *21*(8), 513-521.

Nelson, D. W., & Sommers, L. E. (1982). Total carbon, organic carbon, and organic matter. *Methods of soil analysis: Part 2 Chemical and microbiological properties*, *9*, 539-579.

Porro, D., Pantezzi, T., Pedò, S., & Bertoldi, D. (2012). Interaction of fertigation and water management on apple tree productivity, orchard nutrient status, and fruit quality. In *VII International Symposium on Mineral Nutrition of Fruit Crops 984* (pp. 203-210).

Rhoades, J. D., & Miyamoto, S. (1990). Testing soils for salinity and sodicity. *Soil Testing and Plant Analysis*, *3*, 299-336.

Sandal, S. K., & Kapoor, R. (2015). Fertigation technology for enhancing nutrient use and crop productivity: An overview. *Himachal Journal of Agricultural Research*, *41*(2), 114-121.

Shah, S. A., Haroon, & Amin, M. (2019). Nutrient management of deciduous Orchards (plum) through foliar feeding. *Academia Journal of Agricultural Research*, 7(8): 192-197.

Singh, B. K., Tiwari, K. N., Chourasia, S. K., & Mandal, S. (2007). Crop water requirement of guava (*Psidium guajava* L.) cv. KG/KAJI under drip irrigation and plastic mulch. In *I International Guava Symposium 735* (pp. 399-405).

Singh, Y., Singh, C. S., Singh, A., Singh, A. K., & Singh, K. (2005). Fertigation a key for Hi-Tech Agriculture. *Agriculture Water Management*, *52*(7), 128-149.

Soltanpour, P. N., & Schwab, A. P. (1977). A new soil test for simultaneous extraction of macro-and micro-nutrients in alkaline soils. *Communications in Soil Science and Plant Analysis*, *8*(3), 195-207.

Smith, S. (2001). Agricultural irrigation–fertigation facts: The fundamentals of applying fertilizer through an irrigation system. Online Edition: IBT, March 2001.

Stacewicz-Sapuntzakis, M., Bowen, P. E., Hussain, E. A., Damayanti-Wood, B. I., & Farnsworth, N. R. (2001). Chemical composition and potential health effects of prunes: a functional food?. *Critical Reviews in Food Science and Nutrition*, *41*(4), 251-286.

Steel, R. G. D., & Torrie, J. H. (1980). *Principles and procedures of statistics, a biometrical approach*. McGraw-Hill, New York.

Suman, S., & Raina, J. N. (2014). Efficient use of water and nutrients through drip and mulch in apple. *Journal of Plant Nutrition*, *37*(12), 2036-2049.