

## A Preliminary Study on Plant Nutrients Production as Combined Fertilizers, Consumption Patterns and Future Prospects for Pakistan

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**Abstract:** Fertilizers are artificial substances which contain chemical elements that are required by plants for robust growth and productivity of crops. Fertilizers are applied to soils to increase the soil fertility which is the capacity of soil to supply essential nutrients to plants for their growth and development. Modern chemical fertilizers include one or more elements, but the most important elements in plant nutrition are nitrogen, phosphorus and potassium which are called primary nutrients. Of primary nutrients, nitrogen is considered to be the most important one and is required by the crops in the greatest quantities. Nitrogenous fertilizers mostly used by local farmers include urea (46% N), calcium ammonium nitrate CAN (26% N) and ammonium sulphate (21% N + 24% sulphur). Phosphatic fertilizers include single super phosphate (18% P<sub>2</sub>O<sub>5</sub> + 12% sulphur), Triple superphosphate (46% P<sub>2</sub>O<sub>5</sub> + 1.5% sulphur), Di-ammonium phosphate (46% P<sub>2</sub>O<sub>5</sub> + 18% N) and Mono-ammonium phosphate (52% P<sub>2</sub>O<sub>5</sub> + 11% N + 2% sulphur). Potassium is supplied to plants as K<sub>2</sub>O. Sulphate of potash (50% K<sub>2</sub>O + 18% sulphur) and Muriate of potash (60% K<sub>2</sub>O) are two important potassic fertilizers. In Pakistan, total production of urea was over 4.2 million tons, DAP 0.44 million tons, CAN 0.34 million tons, NP 0.39 million tons and 0.10 million tons of NPK complete fertilizer in 2010-11 with 14 industrial units. Urea, DAP and SOP are used by farming community in greatest quantities, which were available at the price of Rs. 1045, 3236 and 2800, respectively during 2010-11. Sindh leads in terms of more fertilizers use among four provinces. Fertilizers use is much less in Pakistan due to high prices and poor financial condition of farmers. There is need to integrate organic sources with inorganic fertilizers to increase crops yield. Furthermore, farmers need to be aware of importance of inorganic fertilizers use in order to increase crops production and ultimately to ensure the food security of teeming millions.

**Key words:** Fertilizer use efficiency • Organic fertilizers • Plant nutrition • Primary nutrients • Soil fertility

### INTRODUCTION

Agriculture continues to remain the backbone of Pakistan's economy as it contributes 21.4 percent to national GDP (Gross Domestic Product), employs 45 percent of the country's labour force and contributes in the growth of other sectors of the economy [1]. The healthy expansion in agriculture stimulates domestic demand for industrial goods and other services and supplying raw material to agro-based industry, particularly to cotton textile industry which is the largest industry of Pakistan. To feed ever increasing population

and to ensure food security (it exists when each and every one has an access to safe, sufficient and nutritious food at all the times at a reasonable and affordable prices) [2], crops yield increment is indispensable [3-7]. For this, fertilizers which are natural or artificial substances containing the chemical elements that improve growth and productiveness of plants, hold the key [8]. Adequate plant nutrition is one of the basic requirements to achieve the crops yield potential [9]. Fertilizers are also vital to increase the soil productivity which depicts the soil capacity to give the yield of a certain crop under a specified system of management and is measured in terms

of yield per unit area of cropland and time. To maximize the profitability which is the difference between the value of the produce (gross benefit or revenue) and the cost of production, the balanced and timely use of fertilizers is of the utmost importance. Fertilizers have played their role to make sure the agricultural sustainability which is the utilization of agricultural resources particularly land in such a way that production is increased [10] without endangering the resource base for future generations [11-13]. Fertilizers enhance the natural fertility of the soil or replace the chemical elements taken from the soil by previous crops. The use of manure and composts as fertilizers is probably almost as old as agriculture. Modern chemical fertilizers include one or more of the three elements most important in plant nutrition are nitrogen, phosphorus and potassium. Of secondary importance are the elements sulfur, magnesium and calcium. Of primary nutrients, nitrogen is considered to be the most important one and is required by the crops in the greatest quantities. Nitrogen is absorbed by plants either as nitrate ( $\text{NO}_3^-$ ) or ammonical form ( $\text{NH}_4^+$ ). Nitrogen is an integral component of amino acids, proteins, chlorophyll and various enzymes [14]. It is essential for carbohydrate use within plants and stimulates the root growth along with triggering photosynthetic activity. It is particularly important for the quality of leafy vegetables and forages because it encourages above ground vegetative growth and produces succulence [15]. Nitrogenous fertilizers include urea (46% N), calcium ammonium nitrate CAN (26% N) and ammonium sulphate (21% N + 24% sulphur). Phosphorous is absorbed by plants either as primary orthophosphate ( $\text{H}_2\text{PO}_4^-$  predominately in acidic soils) or secondary orthophosphate ( $\text{HPO}_4^{2-}$  predominately in alkaline calcareous soils) [15]. Phosphorous acts as energy currency within plants and is involved in energy storage and transfer as phosphate compounds such as ATP [16]. It is the structural component of nucleic acids, nucleotides, phospholipids, phosphoproteins, coenzymes and sugar phosphates. It is involved in seed and fruit formation and triggers root development. It ensures early maturity, gives greater strength to cereals straw and imparts disease resistant to crops. Phosphatic fertilizers include single super phosphate SSP (18%  $\text{P}_2\text{O}_5$  + 12% sulphur), Triple superphosphate TSP (46%  $\text{P}_2\text{O}_5$  + 1.5% sulphur), Di-ammonium phosphate DAP (46%  $\text{P}_2\text{O}_5$  + 18% N) and Mono-ammonium phosphate MAP (52%  $\text{P}_2\text{O}_5$  + 11% N + 2% sulphur). Potassium is supplied to plants as  $\text{K}_2\text{O}$ . Potassium is believed to be involved in activation of over 60 enzymes in plants. It regulates osmotic potential,  $\text{CO}_2$  assimilation into sugars along with translocation of

assimilates from source to sinks [15]. It is involved in protein and starch synthesis as well as nitrogen uptake. Sulphate of potash SOP (50%  $\text{K}_2\text{O}$  + 18% sulphur) and Muriate of potash MOP (60%  $\text{K}_2\text{O}$ ) are two important potassic fertilizers. In addition to these, complex fertilizers like nitrophos (23%N + 23%  $\text{P}_2\text{O}_5$ ) and complete NPKs are also manufactured in different grades. Contribution of balanced fertilization towards increased yield is from 30 to 50 percent in different crop production regions of the country. One kg of fertilizer nutrient produces about 8 kg of cereals (wheat, maize and rice), 2.5 kg of cotton and 114 kg of stripped sugarcane [14]. Almost hundred percent soils in Pakistan are deficient in nitrogen, 80 to 90 percent are deficient in phosphorus and 30 percent in potassium. Wide spread deficiency of micronutrients are also appearing in different areas [14].

This study was aimed to provide an overview of the different fertilizers production and consumption patterns in Pakistan. It was also planned to give an insight into the uses of different nutrients in Pakistan and to suggest recommendations to increase the fertilizer use efficiency and to suggest guidelines for policy formulation regarding fertilizers.

## MATERIALS AND METHODS

In this study, the data pertaining to the different fertilizers production and uses patterns were collected from Economic survey of Pakistan [1], Food and Agriculture Organization (FAO) [2], Punjab Development Statistics [17], National Fertilizer Development Center (NFDC) Statistics [18] and different related scientific articles. Interviews with farmers, wholesalers and retailers were conducted purposively from April to June 2012 and then October to December 2012 in Faisalabad, Okara, Sahiwal and Pakpattan districts.

## RESULTS AND DISCUSSION

**Cropped Area in Pakistan:** Punjab province continues to remain the food basket of Pakistan [17] with the highest area under crops and due to the production of cereals like wheat and rice. Total cropped area of Punjab in 2001-02 was 16.1 million hectares and it has reached to the extent of 17.23 million hectares in 2010-11 by bringing under the plough those marginal lands that were not cultivated before, but since then, cropped area in Punjab has remained stagnant with out any substantial conversion of marginal and uncultivated lands [17]. Sindh is ranked as the 2<sup>nd</sup> province with regard to cropped area and

agricultural production with total cropped area of 3.45 million hectares in 2010-11, while it was 3.16 million hectares in 2001-2002. Khyber Pakhtunkhwa (KPK) comes at the 3<sup>rd</sup> number with regard to cropped area among the four provinces of Pakistan. Its total cropped area in 2010-11 was 1.59 million hectares against 2 million hectares in 2001-02. It is the only province where cropped area has been substantially decreased in last ten years. Balochistan has the cropped area of 1.13 million hectares in 2010-11 against 0.85 million hectares in 2001-02 [18], despite the fact that it entails the title of being the biggest area-wise province in Pakistan.

**Fertilizers Production in Pakistan:** The first fertilizer production plant established in Pakistan was by Pak-Arab in 1962 in the city of Multan of Punjab province [18]. It started the commercial production of calcium ammonium nitrate (CAN) and in the same year also started the production of urea. Engro chemical Pak. Ltd. plant in Dharki (Sukkur) has the highest urea production capacity in Pakistan and then comes the Fauji Fertilizer Co. (FFC) urea production plant located in Sadiqabad (Rahim Yar Khan). Fauji Fertilizer Bin Qasim is the leading DAP manufacturer, while potassium is being produced by only Engro chemical Pak. Ltd. in the form of complete NPK fertilizers through its plant located in Port Qasim (Karachi). SSP (single super phosphate) which is the only available straight phosphatic fertilizer, its production has been ceased due high costs involved in its production locally along with ammonium sulphate (AS). In addition to DAP, NP (nitrophos) which is a complex fertilizer is being produced by Engro chemical Pak. Ltd. and Pak.-Arab. Currently, total production of urea is over 4.2 million tons, DAP 0.4 million tons, CAN 0.34 million tons, NP 0.39 million tons and 0.1 million tons of NPK complete fertilizer with 14 industrial units [18]. Pakistan imports all

three major nutrient containing fertilizers of nitrogen, phosphorous and potassium (NPK). Nitrogen is the most used nutrient [19-30] and urea is the highest consuming fertilizer in Pakistan. In 2010-11, Pakistan produced 2.64 million tons of N on nutrient base in comparison with 2.13 million tons in 2001-02. Total imports of N nutrient in 2001-02 were 0.178 million tons which reached to 0.383 million tons in 2010-11 [18]. The highest production of N nutrient from 2001-2010 was during 2006-07, when total production was 3.47 million tons. While the highest imports of N nutrient were made during 2009-10, when total N import stood at 0.901 million tons. It was due the worst electricity crisis and diversion of natural gas from fertilizer industry to power generation plants. Phosphorous is also an important nutrient required by crops to give full potential yield along with nitrogen [31-40]. Every year, Pakistan spends a hefty amount of foreign exchange reserve to import P<sub>2</sub>O<sub>5</sub> nutrient, mostly as DAP, SSP and TSP. In 2010-11, Pakistan imported 0.42 million tons of P<sub>2</sub>O<sub>5</sub> nutrient in 2001-02 as domestic production of this nutrient was only 0.142 million tons. However substantial increase in domestic production of P<sub>2</sub>O<sub>5</sub> has taken place as it reached to the extent of 0.423 million tons in 2010-11 due to increase in DAP production and as result of this increased production, the imports were decreased to 0.244 million tons. The highest imports of this nutrient were recorded in 2007-08, when total imports stood at 0.565 million tons. K<sub>2</sub>O is produced and made available in the form of complete NPK fertilizer in Pakistan. The highest production of K<sub>2</sub>O nutrient was recorded during 2010-11 when it was produced in the quantity of 12000 tons [18], solely by Engro chemical Pak. Ltd. through its NPK production plant situated in Port Qasim (Karachi). The highest imports of this nutrient was recorded during 2007-08, when it stood at 23000 tons (Fig. 1).

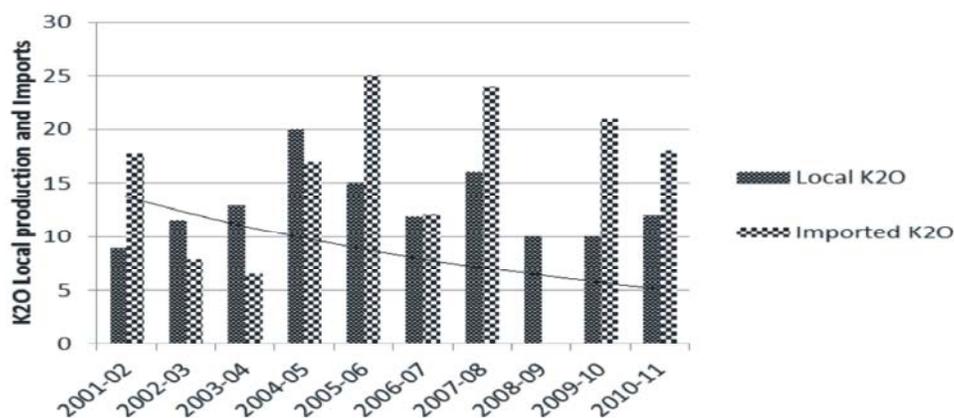


Fig 1: K<sub>2</sub>O production on nutrient basis locally and imports in thousand tons.

**Fertilizer Price Trends and Dynamics:** Prices of fertilizers greatly influence the use fertilizers because in farming, every thing revolve around economics [41, 42] and this factor even becomes more important when majority of the farmers fall in the category of small land holders. In last few years, fertilizer prices have recorded a great boost which has hampered the farmers to use nutrients in required and recommended quantities. A bag of 50 kg urea was available at Rs. 394 in 2001-02, but in 2010-11 it reached to Rs. 1045 (Fig. 2). Similarly a bag of 50 kg DAP attained the price of Rs. 3236 in 2010-11, while it was available at the rate of Rs. 710 in 2001-02. Sulphate of potash (SOP) was available at just over Rs. 2800, while its price in 2001-02 were just Rs.765 (Fig. 2). Calcium ammonium nitrate (CAN) was available at the price of Rs. 270 in 2001-02 and in 2010-11 its price was raised to 850 (Fig. 3). Single superphosphate (SSP) in granular formulation was available to farmers at Rs. 896 in 2010-11

against the price of Rs. 280 in 2001-02. Single superphosphate (SSP) in powder form was sold at the price of Rs. 235 in 2001-02 against the price of Rs. 850 in 2010-11. Triple superphosphate was available at Rs. 2450 in 2010-11 against the price of Rs. 710 in 2001-02 (Fig. 3). The matter of fact is that government continues to provide heavy subsidies on fertilizers intended for small farmrs that was Rs.3.7 billions in 2005-06 and it increased to the extent of Rs.47 billions in 2010-11 (Fig. 4). The majority of farmers in districts of Faisalabad, Okara, Sahiwal and Pakpattan are small land holders with less than 4.5 acres of land on an average. 93% of small farmers in these districts purchased fertilizers from commission shops who charge atleast Rs.500 on urea and Rs.700 on DAP because farmers always have no cash in hand to purchase inputs and as result they are forced to purchase fertilizers on credit and ultimately pay heavy price for this credit.

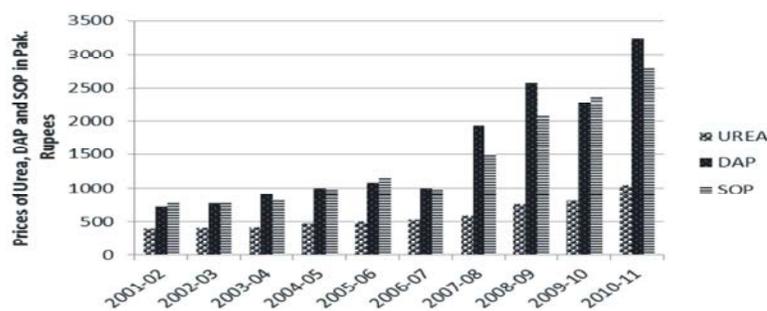


Fig 2: Urea, Di-ammonium phosphate and sulphate of potash price (Pakistani Rupee) trend in Pakistan [18].

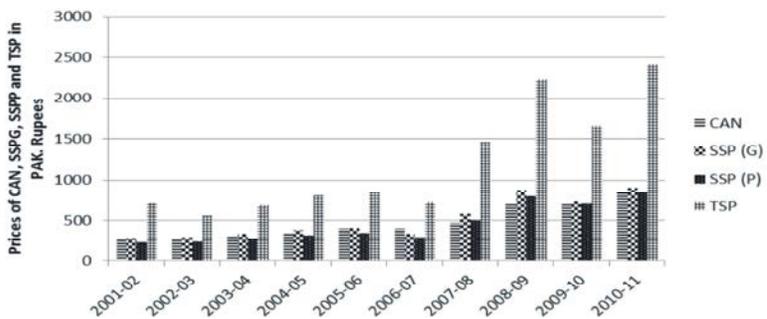


Fig 3: Urea, Di-ammonium phosphate and sulphate of potash price (Pakistani Rupee) trend in Pakistan [18].

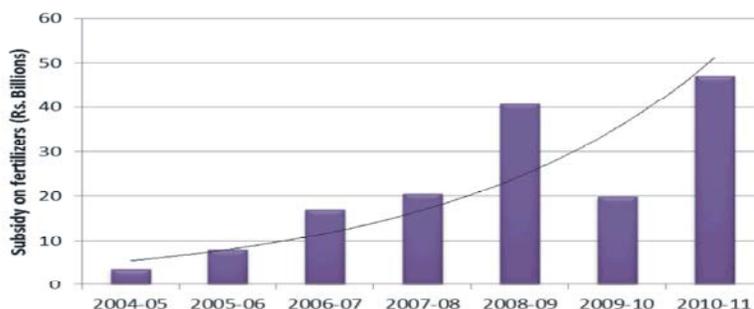


Fig 4: Subsidy (Pakistani Rupee) provided by Govt. on different fertilizers [18].

Table 1: Average use of primary nutrients on per hectare basis in Pakistan [18]

Province	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potash (kg/ha)	Total (kg/ha)
<b>2005-06</b>				
Punjab	116.5	38.8	1.4	156.7
Sindh	169.5	46.8	1.9	218.2
KPK	95.9	19.3	1.0	116.2
Balochistan	84.6	21.8	0.8	107.3
Pakistan	121.9	37.7	1.4	161.0
<b>2006-07</b>				
Punjab	124.8	36.8	1.2	162.9
Sindh	183.2	58.3	1.6	243.1
KPK	98.2	18.1	0.9	117.2
Balochistan	97.1	21.9	0.9	119.9
Pakistan	130.0	37.8	1.2	169.0
<b>2007-08</b>				
Punjab	107.0	41.0	1.9	149.8
Sindh	159.0	61.3	2.3	222.6
KPK	100.0	26.4	1.3	127.7
Balochistan	110.6	28.4	1.2	140.2

**Nutrients Consumption Patterns:** Overall, the use of nutrients by farming community in Pakistan is much less as compared to other countries on per hectare basis. In Punjab, nitrogen nutrient was used at the rate of 132 kg ha<sup>-1</sup> on an average in 2010-11, while Sindh is the leading province in term of nitrogen use on per hectare basis as 156 kg ha<sup>-1</sup> was the quantity of nitrogen nutrient used in 2010-11 (Table 1). The Balochistan comes at the last with regard to the use of nitrogen nutrient among four provinces. Sindh province is also the leading one with regard to P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O uses on per hectare uses with 43 kg ha<sup>-1</sup> of P<sub>2</sub>O<sub>5</sub> and 1.4 kg ha<sup>-1</sup> of K<sub>2</sub>O, while the corresponding figures for Punjab 33 kg ha<sup>-1</sup> and 1.4 kg ha<sup>-1</sup> of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O respectively (Table 1). The overall the ratio of N:P:K nutrients was 1:0.25:0.01, that were supplied to crops on percent basis. It is evident from this statistics that the use of phosphorous nutrient is much less in comparison to the required and recommended quantities along with potassium nutrient. So it becomes clear that why we have not able to achieve the full potential yield of crops as plant nutritional factor is rigorously underestimated and underused. The maximum amount of nutrients is being consumed by wheat crop in Pakistan up to the extent of 19.66 million tons in 2010-11 and wheat was followed by cotton crop which consumed about 0.983 million tons of nutrients in the same year. After cotton, then comes the sugarcane, rice and maize which consumed 0.31, 0.23 and 0.59 million tons of nutrients respectively in 2010-11. Statistics collected from the study area showed that 43% of the farmers used only urea, 51% used both urea and DAP and only 6% farmers used urea, DAP and sulphate of potash in Faisalabad, Okara, Sahiwal and Pakpattan districts during 2012.

**Future Prospects and Recommendations:** On per hectare basis, use of plant nutrients in Pakistan is much less as compared to other countries. Plants cannot thrive well to yield their full potential in the absence of adequate plant nutrients availability along with other favorable soil and climatic conditions. One of the main reasons that came to light while discussions and interviews with farmers in study area was the absence of capital. Farmers continue to remain under heavy debt and being exploited by middle men. Small land holders were hit the hardest because they were unable to supply all the nutrients in required quantities and at appropriate time and result was nominal yields of all staple and cash crops. The vicious cycle of poverty starts with less than optimum use of farm inputs and ends with meager yields. Another major reason observed in the study area was lack of awareness as farmers only used urea and most of them were ignorant to the utility of phosphorous and potassium fertilizers. Only 2% farmers were aware of importance of soil testing before fertilizer application. It was observed that farmers were not properly accessed by provincial agriculture department personnel to make them aware of latest techniques to improve the fertilizer use efficiency. Farmers were of the view that crops fed on inorganic fertilizers are harmful to human being and this misconception has made the use of fertilizers even more underpinned. Large land holders were using nitrogen and phosphorous fertilizers and even some of them were not aware of the utility of potash fertilizers, despite the fact that some of them were even using foliar sprays of boron and zinc for their crops. Thus as long as small land holders are in business of crop production, there is little possibility of using fertilizers in optimum quantities at appropriate times at their own

without government interference. Government needs to provide credit facility through ZTBL at their door steps if it ever intends to ensure food security of their masses. Provincial agriculture departments need to shoulder the responsibility of making farmers aware of the inorganic fertilizers importance in increasing crops growth and yield. They need to be told to integrate organic as well inorganic sources to make crop production sustainable as well as more economical especially for small farmers of the country. Furthermore, government needs to fix fertilizers shortage crisis which emerge time to time only to hit crop production a hefty blow. It is the need of hour to make each and every stakeholder in agribusiness from farmers to agricultural products dealers and from provincial agriculture department to federal government to play their role effectively and efficiently if food security is to be ensured. Food security of teeming millions in the country can only be ensured by increasing crops production as area under plough is decreasing let alone increasing it. Thus farmers should be made aware of the importance of plant nutrition and optimum plant nutrition is bound to increase the production of all major crops such as wheat, rice, sugarcane, maize and cotton.

### CONCLUSION

Plant nutrition is one of the most important factors affecting plant growth and ultimately economic yield. Farmers in Pakistan, especially with small land holdings are not properly aware of the importance of inorganic fertilizers particularly of phosphorous and potassium fertilizers. Fertilizer use efficiency is much low which causes economic losses. To increase crop production and to make the farming business profitable, optimum quantities of fertilizers at appropriate time will have to be ensured. Provincial agriculture departments would have to take responsibility by launching a vigorous and enthusiastic extension campaign to make farmers aware of importance of inorganic fertilizers use in order to ensure the food security of teeming millions. Government should also strive to make subsidized fertilizers in easy access of small farmers. Thus a combined and coordinated effort in making plant nutrition a vital and focused subject by government, farmers, agricultural researchers and extension workers has the potential to increase crops yield significantly.

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