International Fertilizer Industry Association

IFA Technical Conference

Chennai, India
24-27 September 2002

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MAGNUM-P44®, A REVOLUTIONARY PHOSPHATE FERTILIZER (a)

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1. Introduction

- Kemira is a European based chemical group operating worldwide that was established in 1920 in Finland
- Kemira's core businesses are:
  - pulp and paper chemicals
  - water treatment chemicals
  - paints and coatings.
  - specialty fertilizers
- Kemira has production in over thirty countries with 10,207 employees
- Kemira Agro is Europe's second largest producer of specialty fertilizers
- Kemira Agro focuses on new products and service packages to agriculture and the entire food chain.

Net sales in 2001, million euros	2,454
Kemira Agro % of Group net sales	47
Kemira Agro Operating income, million euros	49
Kemira Agro % of Group operating income	34
Kemira Agro personnel at 31.12.01	3,079

2. Sustainable Agriculture Through Micro-Irrigation and Fertigation – Growing Role of Kemira

Kemira Agro believes that it has a crucial role to play in meeting one of the future main challenges, namely ensuring food supply with limited land and water resources to meet the demand of a growing (and generally more affluent) worldwide population.

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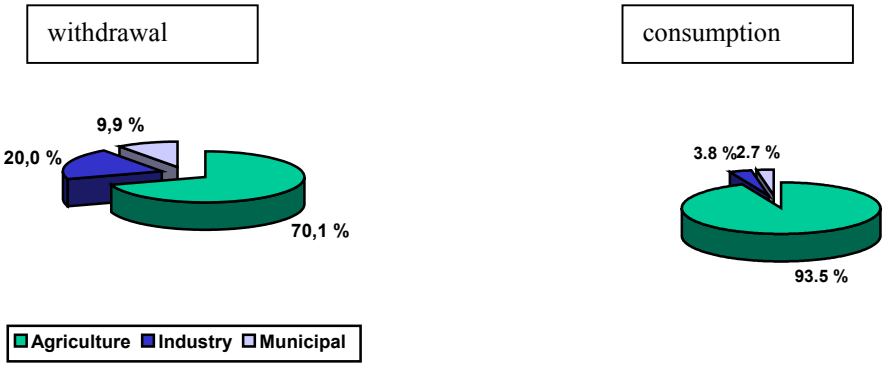
(a) received on 24/06/02

2.1 Agriculture is the largest user of scarce water resources

Only 2.5% of the world's water is fresh, capable of serving the various needs of man, including agriculture. Currently, only around 17% of the world cultivated area is irrigated yet this land accounts for more than 40% of world food production. Agricultural output per unit of water on irrigated croplands is twice the output on rainfed croplands



Increased production to satisfy food demand must essentially come from intensification, not expansion of agricultural area. It is estimated that up to 80 %, of the required increase in food production will come from irrigated agriculture.

2.2 Pressures towards more water efficient irrigation practices are increasing

Since the availability of fresh water per capita is decreasing sharply, pressure on the agricultural community to strive towards sustainability is strongly increasing.

There are 2 major problems associated with water scarcity: water quantity and water quality.

The majority of the countries facing the most acute water shortages over the next 10 to 15 years are located in the Middle East and around the Mediterranean region.

It is necessary to gradually move to more water efficient irrigation practices; i.e. traditional surface irrigation methods should decrease in favour of more water-efficient irrigation systems.

Obviously, this does not mean that surface irrigation will completely disappear in favour of pressurised irrigation in the near future. FAO estimate that worldwide irrigated area will increase from 270 M ha in 1997 to 330 M ha in 2025 (less than 1% per year) but more water-efficient irrigation methods like micro-irrigation are developing much faster (double digit growth in most countries).

	Estimated worldwide hectareage in 1996-1997	Anticipated future yearly growth rate
Total irrigated area	270 Mha	< 1 %
Micro-irrigation	3 Mha	6 to 12 %
Sprinkler irrigation	20-25 Mha	4 to 8 %

Top 10 irrigated countries in 1996

Country	Total irrigated area (M ha)
India	57.0
China	49.9
USA	21.4
Pakistan	17.6
Iran	7.3
Mexico	6.1
Russian Fed	5.4
Thailand	5.0
Indonesia	4.6
Turkey	4.2
Sub-total	178
World total	263

Source: FAO, FAOSTAT Database

Micro-irrigation (i.e. drip irrigation and micro-sprinklers) is generally recognised as the most water efficient irrigation method. Water efficiency in these systems can reach 80-90 % while it only averages 40-50 % under surface irrigation.

Total acreage under micro-irrigation was 1,600,000 ha in 1991 (ICID study conducted by D.A.Bucks). It was estimated at about 3,000,000 ha in 1996 and should reach approximately 4,000,000 ha in 2000.

Largest markets for micro-irrigation:

Countries	Hectareage 1997/1998
USA	> 800,000 ha

Spain	> 400,000 ha
Italy	> 300,000 ha
Brazil (N.E+S.E)	> 300,000 ha
Mexico	> 200,000 ha
South America (Chile/Argentina/Peru)	> 200,000 ha
Egypt	> 200,000 ha
Morocco	> 150,000 ha
Australia	> 150,000 ha
China	> 100,000 ha
Turkey	> 50,000 ha
Tunisia	50,000 ha
TOTAL	**> 2,700,000 ha**

2.3 The advantages of the micro-irrigation systems can be summarised as follows (Papadopoulos, 1996b)

- Significant water saving. Since conveyance losses are eliminated and soil surface area wetted is restricted, efficiencies higher than 80% can be achieved.
- Increased yields. The root-zone of the crops with the modern irrigation methods remains continuously moist and the plant is not, therefore, subject to stress cycles.
- In addition, the required fertilizers can be applied with the irrigation water (fertigation), whenever and where they are exactly needed by the plant.
- They may be used for full chemigation (fertigation, herbigation, insectigation, fungigation, nematigation).
- The area between plant rows of trees remains free and dry enabling spraying and harvesting to be done even during water applications.
- Utilisation of steeper slopes and problem soils otherwise unsuitable for irrigation with the conventional methods of irrigation.
- Poor quality saline water can be used with the drip and minisprinkler irrigation methods, because by maintaining high moisture in the soil with frequent irrigations the salt that is being added with the irrigation water is diluted and remains acceptable.
- They can operate with a limited flow rate at a relatively low pressure head. One bar for drippers and 2 bars with minisprinklers. This means savings in the cost of the pump, fittings, lines, energy and labour.
- They require limited labour. They can be automated by using automatic metering valves, electronic tensiometers, time switches, etc.

Fertigation is the application of water soluble fertilizers in the irrigation water, either with each irrigation or periodically to the wetted volume of the plant in the active root zone.

Yields (kg/ha) of some crops irrigated with pressurised micro-irrigation systems as influenced by fertigation and traditional fertilisation (Papadopoulos, 1996b).

Crop	Fertigation	Traditional fertilisation
Potatoes	70,000	37,000
Carrots	54,000	42,000
Tomatoes (greenhouse)	350,000	150,000
Tomatoes (open field)	180,000	55,000
Cucumber (greenhouse)	300,000	140,000
Watermelon (open field)	115,000	60,000
Strawberries (low tunnels)	48,000	20,000

Micro-irrigation is the first irrigation method that can potentially maximise productivity while conserving soil, water and fertilizer resources and simultaneously protecting the environment (Phene, 1995).

2.4 Main water-soluble fertilizers used in micro-irrigation are

- KNO_3 (+/- 1,200,000 tons worldwide) Kemira Potassium Nitrate
- K_2SO_4 Kemira Potassium Sulphate
- Urea phosphate Kemira Magnum-P44
- WS-NPK's Kemira Ferticare and FerticareAce
- Calcium nitrate
- MAP-DAP
- MKP (+/- 100,000 tons worldwide)

2.5 Critical characteristics of water soluble fertilizers

- water solubility
- compatibility with other fertilizers
- pH
- total nutrient content
- safety
- purity
- appearance
- easiness to use
- possible side effects on crop and soil

3. Kemira Emirates Fertilizer (KEFCO)

3.1 Magnum-P44® Urea Phosphate - Production Process Description

Kemira's new urea phosphate production plant is located in Dubai, UAE with a capacity of 30,000 tons annually. Kemira Emirates Fertilizer (or known as KEFCO) uses technology developed by Kemira at their Finland plant site. Briefly, the urea phosphate process is as follows:

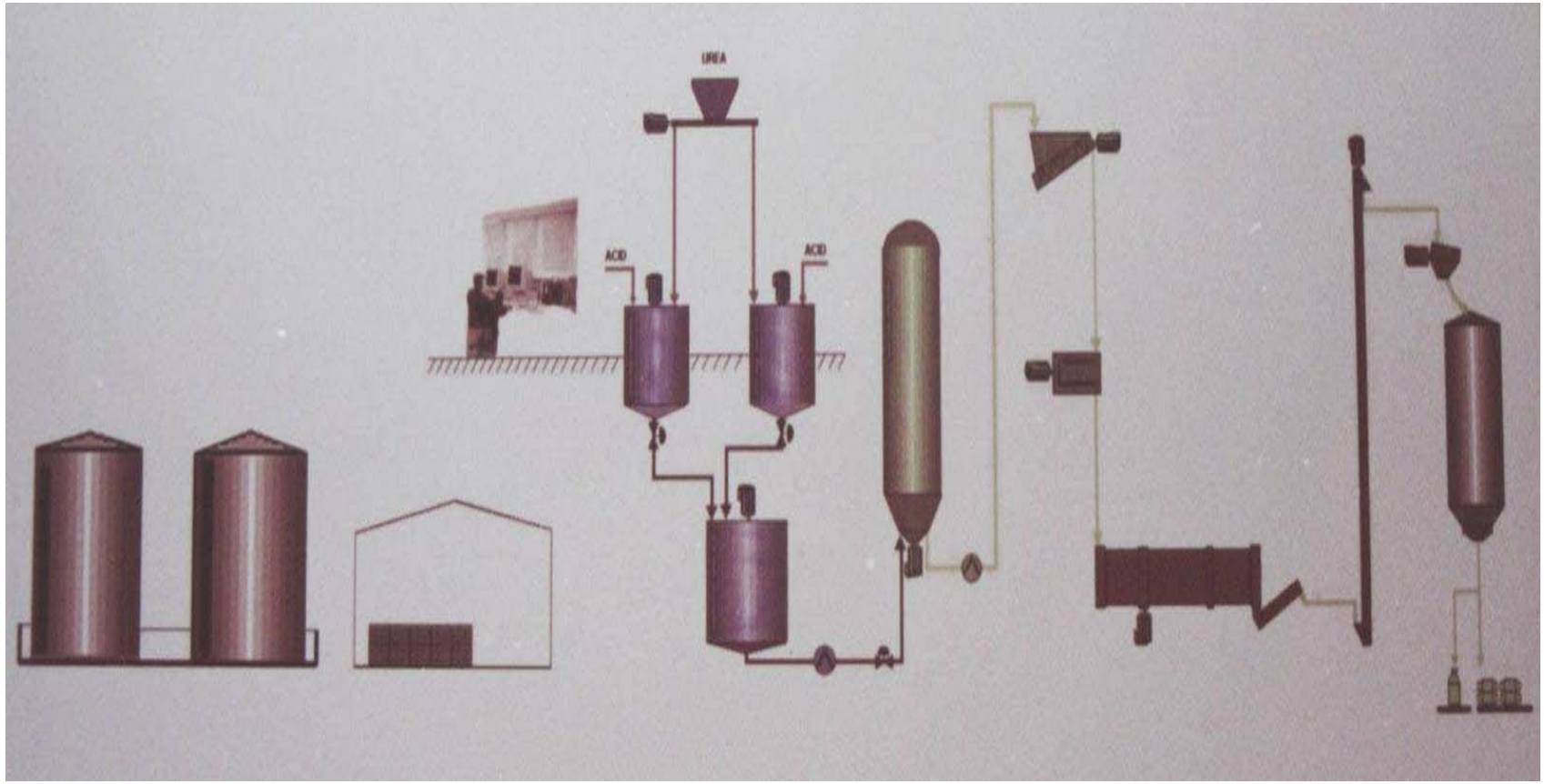
The two main raw materials are imported into the plant with bagged urea arriving on trucks and phosphoric acid arriving by ship. These two materials are introduced into two reactors and stirred. During this reaction process, the urea does not break down, rather it attaches itself to a molecule of phosphoric acid to form an adduct.

This urea phosphate slurry is drained from the reactors and pumped to a crystalliser where it is cooled and concentrated. The resulting super-saturated slurry is then pumped to a centrifuge to separate the crystals from the mother liquor. Upon leaving the centrifuge, the crystals, which have a pH of 1 to 3, are dried, screened and bagged. The mother liquor is stored and further processed into a saleable fertilizer.

KEFCO's Zero Discharge Policy makes this plant environmentally friendly. All liquid waste streams are captured and internally recycled. A high-efficient ammonia scrubber is installed that exceeds the strictest ammonia emission standards.

Kemira Agro Oy decided to make UP one of the cornerstones of its fertilizer business for micro-irrigation. Even though there are some other small UP manufacturers as well, Kemira Agro Oy is still the only UP exporter throughout the world under commercial name Magnum-P44 TM.

Urea Phosphate Process Diagram



3.2 Process Problems/Solutions

- Corrosion: 316L stainless steel on all wetted parts
- Plugging: immediate steaming of lines.
- Sticky product: high level of impurities on crystal.
- Wet product: high level of impurities on crystal.
- Low yield (<80%): Phosphoric acid source

Magnum-P44® Urea Phosphate – Why Demand For This Multi-function Fertilizer Is Increasing.

Pressurised fertigation systems are gaining rapid acceptance, mainly due to the benefits realised from effective nutrient feeding and efficient water use. To further enhance and optimise these benefits, urea phosphate is rapidly gaining wide acceptance as the water-soluble fertilizer of choice.

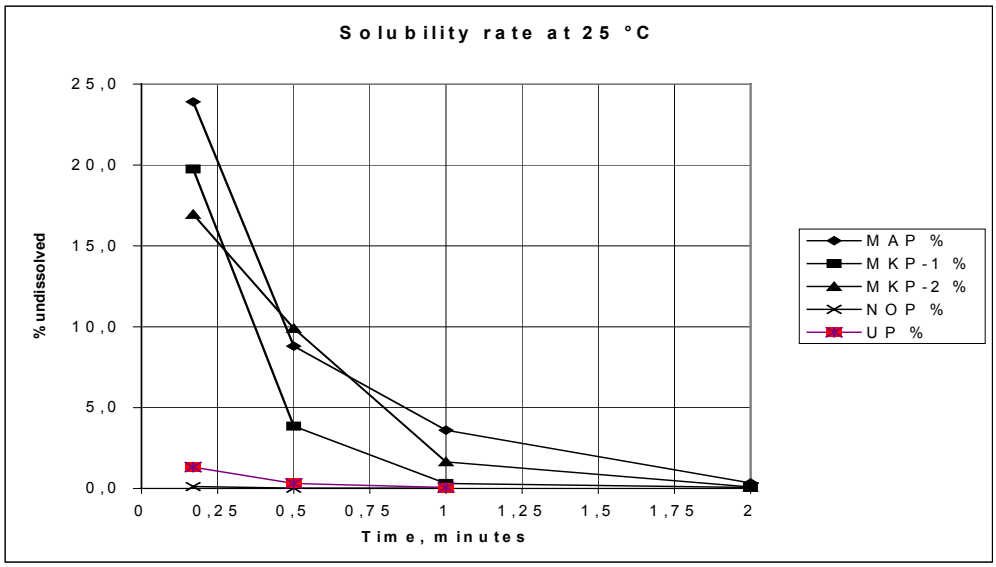
Magnum-P44 is water-soluble, acidic, contains 18% nitrogen and 44% phosphorus. The white crystalline powder quickly and completely dissolves in water and is best suited for pressurised fertigation systems as well as foliar applications.

Magnum-P44 has a number of agronomic advantages that have been demonstrated by researches over the last twenty years. These are:

3.2.1 Solubility

Water-solubility and compatibility of the fertilizers are critical parameters.

Solubility rate tests show that Kemira Agro's Magnum-P44 dissolves 16 times faster than MAP; and 12% faster than MKP; thus requiring less energy and time for complete mixing



Complete dissolving the desired amount of fertilizer is essential in fertigation systems, thus making high water solubility critical because undissolved solids can cause flow restrictions and plugged nozzles. Magnum-P44 has excellent solubility. Per litre of water, 960 grams of

Magnum-P44 can be completely dissolved compared to 408 grams of DAP and 272 grams for MAP.

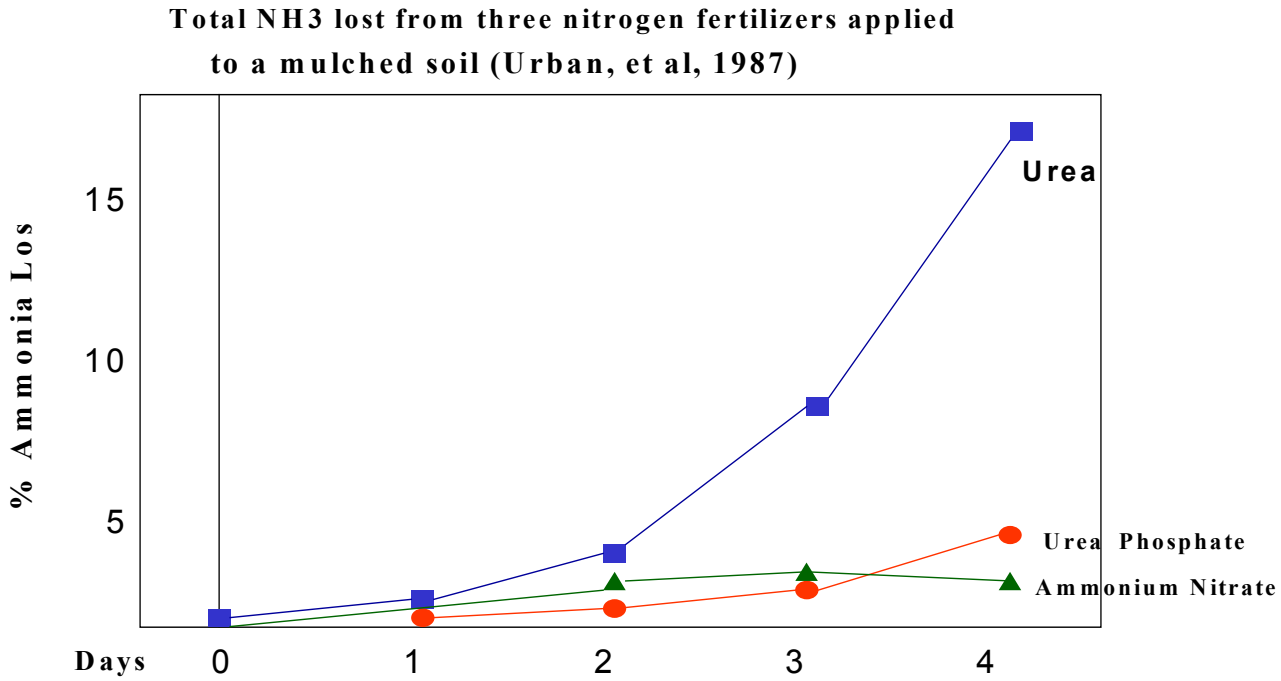
3.2.2 Acidity

Magnum-P44® is acidic making it very suitable for use with 'hard' irrigation water by preventing blockage of the pipes and nozzles. Clogging of such equipment is particularly problematic where irrigation water contains high concentrations of calcium and magnesium. By acidifying the water, Magnum-P44® eliminates plugging potential by reducing the carbonate levels. Regular use of urea phosphate removes mineral build-ups in existing pipes and nozzles and keeps the system operating as desired. Under normal conditions, no extra acid treatment is required if UP or UP-based fertilizers are applied.

Magnum-P44® is mainly used in alkaline soils (e.g. the Middle East, South America and the Mediterranean countries) because lowering the soil and water pH improves the availability and uptake of phosphorous and other micronutrients such as iron, zinc, and manganese.

3.2.3 Nitrogen volatilization

Research with Kemira's Magnum–P44® showed a reduction of volatilisation losses of fertilizer nitrogen. This major benefit is due to the fact that acidity of Magnum-P44 deactivates soil urease enzymes and slows urea hydrolysis near the soil surface. This effect lasts a considerable time, even in highly calcareous soils, allowing the urea to be taken up by the crop.



3.3 Applications

Magnum-P44® is a very versatile fertilizer and has therefore different applications:

3.3.1 Fertigation

Mixed with water in irrigation systems, Magnum-P44® is ideal for alkaline soils. Magnum-P44® provides essential nutrient elements during the important growth stages of plants.

As a source of phosphates and acid, Magnum-P44® avoids precipitation of calcium and magnesium which cause clogging in the irrigation systems. Magnum-P44® keeps pipes and nozzles clean: the water and fertilizers are distributed evenly and consistently.

3.3.2 Foliar applications

Magnum-P44® can be sprayed on plants while spraying with insecticides/pesticides. An additional bonus is achieved by using the urea phosphate to clean the spraying equipment and applying a dosage of fertilizer at the same time.

Magnum-P44® can also be used with other foliar fertilizers such as potassium nitrate, magnesium nitrate, urea, and trace elements without the worry of plugging the spraying equipment.

3.3.3 Raw material for soluble NPK fertilizers

In addition to this straight use in fertigation & foliar applications, Magnum-P44® serves as a raw material to produce a wide range of ws-NPKs called FerticareAce, all including also micronutrients.

The range covers 9 standard grades; however, a great number of other formulations are made annually.

Kemira NPK grades produced from Magnum-P44®

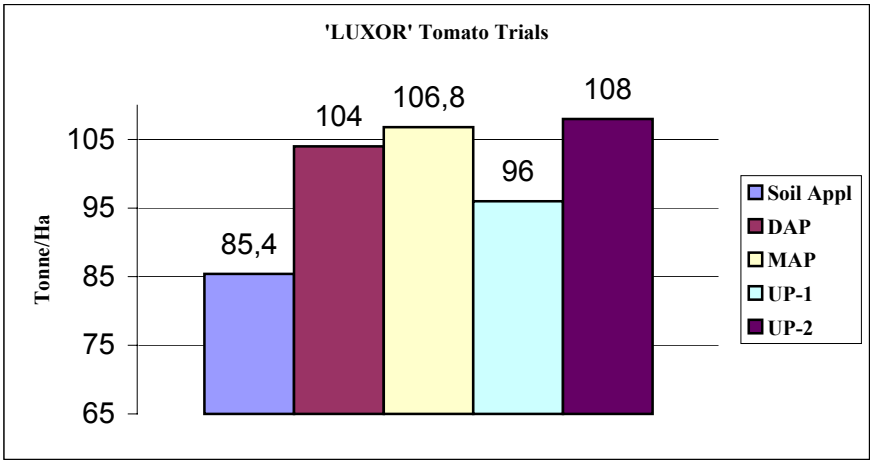
N-P-K grades	Growth stage
8-42-14	for beginning of season
13-40-13	for good establishment
10-24-24	for seedling production
14-11-25	for vegetable production
17-9-26	after flowering period
11-9-35	for bananas and other crops with high K demand
18-18-18	Balanced for any crop
19-6-20	for flower production
20-5-10	for vegetative growth

3.4 Trials

Considerable research work has been done with UP in fertigation on vegetables and in Mediterranean conditions. These trials were conducted on silty clay with 50 to 60% of $CaCO_3$ throughout the soil profile to a depth of 90 cm.

The pH of the soil ranged from 8.2 to 8.4 and that of irrigation water from 7.8 to 8.0. UP has been compared with other water soluble P sources, and UP has repeatedly out-yielded the other P sources, like MAP and Diammonium Phosphate (DAP).

It was also shown in leaf analysis that in the beginning of the season the P uptake by tomatoes was higher in the UP treatment, compared with other P sources (Papadopoulos 1997).



1.Soil application of N, P and K + drip irrigation: AN, TSP and SOP, dosage equal to treatments of 2, 3, and 4.

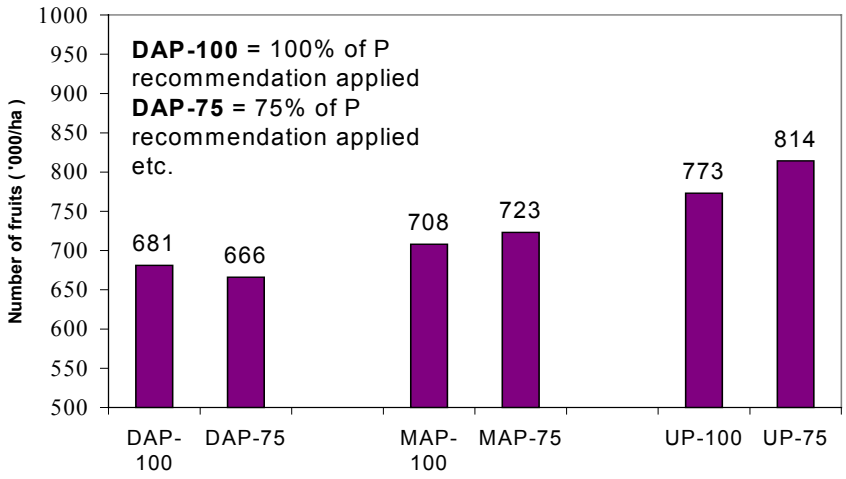
2.DAP 150 – 108 – 282

3.MAP 150 – 108 – 282* local recommendation for tomato

4.UP-1 150 – 108 – 282

5.UP-2 150 – 80 – 282

Figure 2. Number of eggplant fruits ('000/ ha) in different fertigation programmes (Kemira Magnum P44 versus MAP, DAP)



More trials results performed in different countries under different conditions & crops are available under request.

4. Conclusions

Magnum-P44®:

- **is an innovative phosphate source for fertigation**
- **is a unique product with additional agronomic advantages like increased efficiency of nutrient uptake and reduced nitrogen volatilisation losses**
- **performs better in terms of yield and income than other fertilizers under alkaline conditions**
- **is the best choice in alkaline-neutral soils and/or alkaline-neutral irrigation waters**