SYSTEMIC APPLICATION

FOLIAR

New methods and products wind in and around the agricultural industry on a regular basis and farmers are asking each other and those who supply these new methods and products, "Can I get enough fertilizer to raise my crops with a profitable return," or "will the fertilizers work efficiently and successfully?" That is what agriculture is all about, having products and methods that afford farmers success and professionalism in their industry, and to provide a quality product at a profit for their time and experience.

A recent highly successful "new addition" of farming is the HUMA GRO® foliar application of nutrients. It is proven that not only can plants absorb nutrients through the roots, but also through the foliage, the fruit, the twigs, the trunk, and even the flowers. The new products for this method of getting nutrients into the leaf, are successful when using the HUMA GRO® foliar-applied nutrient products.

HUMA GRO® foliar feeding, a significant milestone in agricultural progress in crop production, has become an established practice in this generation. Not only does it produce quick, visible results, but it increases the effectiveness of fertilizer applications to soil, thus reducing total fertilizer costs over the long haul. With the increasing acceptance and use of this effective and efficient tool in farm management, and the timely HUMA GRO® tissue testing of crops, we begin to see a vast opportunity for even higher quality crops and profitability. With combinations as HUMA GRO® foliar and tissue testing, growers have an opportunity to exercise almost precision control over crop nutrient levels.

Advantages of HUMA GRO® foliar feeding are numerous. To achieve a certain nutritional status, the amounts of plant food required with foliar sprays are considerably less than when the same nutrient is applied to the soil. HUMA GRO® foliar feeding increases crop ability to resist adverse conditions such as heat, cold, wind, disease, and insects. Cold, wet, springs which slow plant growth and delay maturity do not have as devastating an effect when plants are foliar fed with the HUMA GRO® nutrients and special products.

EARLY EXPERIMENTAL DEVELOPMENT OF FOLIAR FEEDING

FOLIAR FEEDING

By: Dr. H.B. Tukey
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OBJECTIVE:

To monitor and test FOLIAR APPLICATIONS (with the radio-isotope technique, provided by the U.S. Atomic Energy Comm.) of nutrients in an attempt to evaluate the relative efficiency of FOLIAR APPLICATIONS of nutrients and SOIL APPLICATIONS of nutrients.

INTRODUCTION:

I appreciate the opportunity to tell you something about what I think is one of the most exciting new developments in agriculture, namely, that not only can plants absorb nutrients through the roots, but also through the foliage, the fruit, the twigs, the trunk, and even the flowers.

Most people believe that plants can get their food only from the soil. This has long been the classical belief, "the law of nature". Today, it is known that this is not the only way! It has been demonstrated that by spraying mineral nutrients on the leaves, fruit, or any above-ground parts of the plant, the plant can be fed! It is now known that non-root absorption of mineral nutrients can take place through above-ground parts of the plant.

METHOD

A tool was needed which would distinguish what was absorbed by the leaf from that which was taken up by the roots; one that would prove whether absorption took place, where it was absorbed, and whether the nutrient traveled through the plant. The radio-isotope was the tool. Michigan State University began investigating above ground absorption of mineral nutrients by plants, using radio-active phosphorus. Their experiment was to find out if absorption could take place, if radio-phosphorus was transported to other parts of the plant, the areas of active growth, etc.

EXPERIMENT

Bean seedlings were started in coarse sand, then they were transferred to aerated solution cultures, so as to control their growth closely, and obtain soil-free roots for radio-chemical analysis. With a supply of uniform plants for experiments using the isotope technique, radio-active phosphorus was applied to the upper surface of each of the primary leaves. After treatment, plants were harvested at intervals, separated into "treated" and "untreated" pots, and dried in an oven.

By determining the total radio-activity applied, and the amount in each plant part, it was possible to calculate the percentage of "tag" nutrients absorbed. A standard scale gave an account of the radio-activity in the roots, stems, and leaves of the various plants tested. The results were encouraging. Nitrogen, for example, may be applied in the form of urea. The rate of nitrogen absorption from urea usually corresponds to its rate of enzymatic-hydrolysis.

Several plants were tested with interesting results. By plotting the tolerance in grams per liter of concentration of urea by plants, against the relative rate of utilization. The plants which tolerate the least concentration of urea, the cucumber, tomato, the corn, utilize urea most rapidly. The peach, potato and cherry, which tolerate the greatest concentration of urea, utilize it more slowly. The apple is somewhere between.

Other elements of importance to plant nutrition which were studied in relation to foliar absorption and sodium,magnesium,sulfur, chlorine, potassium, calcium, manganese, iron, copper, zinc, lobydium, strontium, molybdenum, and barium.

Using radio-isotopes of these elements as tracers, and using techniques such as those used in investigation of radio-active phosphorus (Michigan State University), more information was accumulated on absorption of above-ground parts.

Potassium, sodium, and lobydium, were found to be rapidly absorbed, and highly mobile. Phosphorus, sulphur, and chlorine, were absorbed at a slower rate, but were also mobile and were transported at a rapid rate. Manganese, zinc, copper, and molybdenum were found to be slightly mobile. Calcium, strontium, barium, iron, and magnesium were readily absorbed but did not move out of the leaf to which they were applied.

The radio-isotope technique had revealed a great deal about absorption of nutrient by above-ground parts, that non-root absorption was a fact, and the distribution pattern of the most significant elements in plant nutrition had been determined.

EXPERIMENT #2

To evaluate the relative efficiency of FOLIAR-APPLICATIONS of nutrients and SOIL-APPLICATIONS of nutrients three kinds of soil were used: sandy loam, clay loam, and an organic soil. Uniform tomato plants were used as test specimens. The treatments were replicated and randomized. Radio-active phosphorus was used again as the "tag" nutrient. Soil application versus foliar application were used to determine which was the most efficient?

Three weeks after initial foliar and soil applications, the fruit was again harvested, and assayed for both radio-activity and total phosphorus to determine the percentage (%) contribution from the two methods of application (foliar-soil). Analysis of the harvested fruit revealed that the foliar application was more efficient than the soil application in the three soil types.

CLAY LOAM and organic: Foliar application were six (6) times more efficiently utilized than the soil application.

SANDY LOAM: Foliar application was utilized twenty (20) times more efficiently than in the soil application.

Like foliar applications were applied to the skin of developing tomato fruit, and were found later to have been absorbed into the flesh of the fruit. Dormant fruit trees were sprayed utilizing the radio-active "tag" nutrient method, and in later developing buds, the leaves, the flowers, and fruit were measured. Dormant sprays were found to supply nutrients when natural conditions hinder or prevent root absorption. Foliar sprays on crops such as tomatoes, beans, corn, and potatoes, contributed significantly to mineral nutrient requirements, and increased yields.

SUMMARY:

Many modern agricultural practices, overhead irrigation, misting, spraying for pest control, already utilize the application of foliar nutrients, pesticides, herbicides, to above-ground plant parts. By foliar applications, control over nutritional needs can be exercised in a degree never before thought possible. Black-heart in celery is prevented by calcium sprays; rosette of peaches is prevented by applying foliar zinc solutions. Urea-nitrogen sprays improve the fruit set of apples. Magnesium in nitrogen spray supplement root absorption in tomatoes during the critical stages in flowering, or in fruit development, when demands are high and root-uptake is inadequate. Nutrients can be applied to the branches of winter injured fruit trees to promote recovery where it is impossible for the above-ground part to be adequately supplied with minerals from the roots. It is entirely possible to extend the area of crop protection into those regions where growth is limited by low temperatures, which limit the uptake of nutrients by the roots alone, and to increase significantly the productivity in those areas. In fact, experiments have been conducted in which crops such as beans, have grown to maturity with no nutrients supplied to the roots whatsoever, all being supplied through foliar application.

CONCLUSION:

We have seen that materials are absorbed by the plant and move rather freely in the plant. The amounts may at first seem relatively small, but to offset this handicap, the efficiency rate is high! In fact, this is the most efficient method of applying fertilizer to plants that we have yet discovered. If we apply these materials to the leaves in soluble forms, as much as 95% of what is applied may be used by the plant. If we apply a similar amount to the soil, we find that only about 10% of it is used. this is a very dramatic finding!

There is little doubt that HUMA GRO® foliar applications of nutrients are the most effective methods of fertilization. When plants have sufficient leaf area, HUMA GRO® foliar feeding can make an important contribution toward total nutrient requirements.

Nutrients applied to the soil are less effective due to many contributing factors present in the soil. The chemical nature of a given soil the many soil micro-organisms, soil types, organic matter content, pH range, moisture and soil temperatures, chemicals that may have been applied such as herbicides, pesticides, insecticides, and fumigants allplay a part in uptake by plants. This means that efficiency of any fertilizer/nutrient applied to the soil can be quite low.

HUMA GRO® foliar sprays actually increase the effectiveness and utilization of solid fertilizers by changing the nature of the plant root exudates so that fertilizers are better assimilated by plants. Such stimulation or growth has often been observed and it explains why such dramatic responses are seen from application of only small amounts of nutrients per acre.

HUMA GRO® foliar nutrients applied in frequent, small dosages are more beneficial than large amounts applied less often. Multiple applications from 2 to 6 times during the season prove more economically feasible. Sprays should be spaced from 7 to 30 days apart.
HUMA GRO® foliar nutrient sprays are compatible with most fungicides, insecticides, growth regulators, and antibiotics, but because there are some incompatible compounds, the safest way is to apply foliar feeds separately. (see "Mixing Products," in this booklet).

Whether HUMA GRO® foliar are used to supplement soil fertilizers or to overcome some specific stress conditions, they are the best insurance for top quality crops with maximum yields.

HUMA GRO® foliar feeding, (Systemic Application) with proper tissue sampling and testing can be an unbeatable combination to realize greater profits for the grower!

MIXING HUMA GRO® PRODUCTS FOR FOLIAR APPLICATION:

1) Use a large enough container to adequately handle the basic mixture, plus room for at least half again as much water.

2) The container should be fiberglass, plastic, stainless steel, or rubber lined, and capable of withstanding extreme heat exchanges.

3) A good stir rod such as a 1 1/4" PVC pipe.

4) A 3-gallon measuring bucket with a handle.

5) A 1-quart container with oz. or ml. increments.

6) HUMA GRO® products should be mixed from acid to base: 0.0 - 13.0 pH.

As a rule of thumb, leave the potassium until very last and add slowly. Reaction will be immediate and with a little patience, should mix in well.

PRODUCT pH

SUPER PHOS	0.8	ZAP	3.9
PHOSPHATE	1.2	MANGANESE	4.0
ZINC S.E	1.5	44-MAG	5.3
SULFUR	1.6	PEK	6.5
MICRO F	1.7	NITROGEN	6.5
MICRO	1.8	38 SPECIAL	7.0
BREAKOUT	2.0	LASE	7.3
VITOL®	2.3	START-L	7.4
CALCIUM	2.5	BORON	7.5
ZINC	2.6	BLEND	8.6
COBALT	2.8	MOLYBDENUM	9.0
COPPER	2.8	SILICA	9.5
IRON	2.9	JACKPOT	13.8
Z-MAX®	3.0	POTASSIUM	13.9

HELPFUL NOTES:

A) **When mixing POTASSIUM, be VERY careful! Do NOT use a 1:1 ratio of POTASSIUM and PHOSPHATE.** The product will heat and may solidify after cooling. Try to keep at least a 2:1 ratio of PHOSPHATE to POTASSIUM or reverse. POTASSIUM and PHOSPHATE, or any acid combination, will react with POTASSIUM by foaming or heating. Always mix into the volume of water you are spraying to avoid these problems.
NOTE: POTASSIUM is a very active product that can be corrosive to aluminum.

B) BORON in cold conditions will precipitate to a crystalline structure. This is not the BORON but rather the salts precipitating and the crystals can be discarded.

C) VITOL is loaded to the maximum. Anything else added to it must be suspended with additional water.

D) IRON is more acid than PHOSPHATE and much more corrosive to equipment. Contain only in fiber glass, plastic, rubber-lined or stainless container. Clean thoroughly. Apply immediately. **IRON will stain.**

E) When CALCIUM is added to an alkaline system (pH 7 to 13), it tends to precipitate to a granular form. More water and agitation is needed to bring it back into solution.

F) Many of the HUMA GRO® products appear to separate in the containers. Simple agitation before mixing should bring continuity to the whole product. BORON, as noted, should be poured off so as not to break up or agitate the crystals, if present. Crystals can then be discarded. **(NOTE: Items B & J)**

G) It is important that containers are marked properly after foliars are mixed. All HUMA GRO® products are marked with a lot number, of which the first 3 digits represent the product number. If any concerns arise, this lot number (a 13 digit hand stamped number on label or bottom of jug) in it's entirety should be referred to in all communications with the HUMA GRO® office. A specific product sample is maintained on file at the corporate office for at least one year.

H) Most insecticides or herbicides can be mixed with HUMA GRO® products. However, a trial mixture in a small quantity is highly recommended before mixing the entire batch. Follow **caution** on labels when mixing herbicide.

I) Some products could have sediment on the bottom . To bring these products into solution, hold the 2.5 gallon upside down and strike with the palm on your hand or fist until the sediment is released from the bottom. The sediment will now go into solution when the container is shaken.

J) ZAP is a highly concentrated dynamic formulation and under certain temperature conditions may form salt crystals some times quite large in size. These crystals can be separated from product and dissolved in water if desired but material is a salt precipitant and can be discarded. As a general rule keep all containers tightly closed. Evaporation from open container will also cause material to crystalize.

CAUTION:

When applying HUMA GRO® custom formulations:

1) Apply early in the morning or late in the evening when temperatures are below 80° if possible.

2) Never apply in the heat of the day.

For checking compatibility with other agricultural chemicals, always use a "jar-test" first. Mixing ratios of each component in the jar, including the ratio of water per acre. If mix thickens or becomes pasty; add more water or a wetting agent. This will solve most mixing problems. In some areas the water used in the mixing will have a large amount of salts that may cause mixing problems. Water softener in this case will help.

Spray-equipment used to apply other chemicals may cause a problem with the HUMA GRO® products. The "chelating" materials in the HUMA GRO® foliars are very active. They will pull chemicals which have lodged in the surface of metal and polyurethane tanks, seams, joints, connections and in the hoses. Some problems may result. We suggest that a pint of BLEND with water be run through the equipment first to remove most of the chemical residues.

HUMA GRO products are very concentrated. Always mix them into the volume of water you are going to spray. **Do not mix the HUMA GRO® concentrates together, <u>they will react,</u>** sometimes forming a thick paste. This does not hurt the products but many think it does. By adding water they will go into solution.

Non-ionic wetting agents are helpful in keeping your custom formulations in solution.

Please try to use your inventory of HUMA GRO® complexed products. Don't carry over through the winter if possible, because of the high level of concentration. Any loss of liquid through the cap may cause crystallization. When this happens the inert salts combine with the carbon. This does not hurt the active ingredient, but it looks bad to the farmer. Most of these problems can be solved by adding a little Phosphate and water. This will bring crystals back into solution in most cases.

PLANT TISSUE ANALYSIS

INTRODUCTION

A chemical analysis will determine the nutritional status of a specific part of a plant. Plant analysis will verify a suspected nutrient element deficiency or monitor its nutrient element status for evaluation of a fertility program. A plant analysis can be useful in distinguishing between symptoms caused by physical, or environmental factors. In evaluating plant abnormalities, make a comparison between samples taken from normal plants and abnormal plants in the same area.

Plant analysis is more effective when used in reference with a soil analysis.

SAMPLING INSTRUCTIONS

The accuracy of a plant analysis depends on how the sample is taken and handled. Use the following procedures to obtain quality samples.

1) Sample only leaves or parts of plants of the same age and relative position on the plant. Sample a sufficient number of plants to overcome the factor of plant variability (usually 20-30 plants).

2) When sampling mixed stands (such as legume and grass mixture); separate the plant species. If there are no specific sampling instructions for a crop, a good rule of thumb is to sample the upper-most, recently matured leaves.

3) If a deficiency symptom appears, sample plants should be sampled when the visual symptoms appear. Keep in mind that plants that have been under stress for some time may not give a true picture of their nutrient element status.

4) Do not take leaf samples from plants obviously damaged by disease, insects, or chemical injury unless such damage is the objective of the study. Do not include dead plant material in a tissue sample.

HANDLING & PACKAGING

1) To avoid decompositions in transit plant samples should be air-dried to approximately 10-20% moisture before shipping.

2) If possible, avoid soil-covered or dusty leaves. If leaves are dirty you may brush or wipe them with a damp cloth, or wash in a very mild detergent solution and rinse in running water.

3) Do not place fresh plant tissue in plastic bags or tightly sealed containers unless samples are dry. Use heavy paper bags with perforations.

4) Fill out a sample information sheet for each sample submitted. If results of a recent soil test are available, include them on the information sheet.

5) Ship plant samples via the best method of transportation considering time and cost variables.

PLANT PORTION FOR SAMPLING

FIELD CROPS	WHEN TO SAMPLE	PLANT PART TO SAMPLE	NUMBER OF PLANTS TO SAMPLE
Alfalfa	At pre bloom stage or before	Top 3 inches of plant	45-55
Cereal Grains (including rice)	Seedling stage	All the above ground portion Prior to heading	50-75
		First fully opened leaf from top of plant	30-40
	After heading	Flagstaff	
Clover	Prior to bloom	Mature leaf blades about 1/3 of the way down the plant	50-60
Corn	Seedling stage	All the above ground portion	25-30
	Prior to tasselling	The fully developed leaf below the whorl	15-20
	From tasselling to silking	The leaf at the ear node or the one above or below it	15-20
Cotton	Any stage	Youngest fully mature leaves or main stem	30-35
Hay, forage, or Pasture grasses	Before seed head emerges	First fully opened leaf from top or at the stage for best quality	50-60
Milo-sorghum	Before or at heading	First leaf fully out of whorl	20-25
Peanuts	After bloom begins	Fully developed leaves from top of plant	45-50
Soybeans	Seedling stage or	All the above ground portion	20-30
	Prior to maturity initial flowering	Fully developed leaves at the top of the plant	20-30
Sugar Beets	All season	Fully mature leaves midway between the younger center leaves and the oldest leaf whorl on the outside	30-35
Sugar Crane	All season	Fourth fully developed leaf from the top	25-30

FRUIT & NUT CROPS	WHEN TO SAMPLE	PLANT PART TO SAMPLE	NUMBER OF PLANTS TO SAMPLE
Apple, Apricot, Almond Cherry, Peach, Pear, Prune	Mid-season	Leaves near base of current year's growth	75-100
Grapes	End of bloom period	Newest fully mature leaves	75-100
Lemon-Lime	Mid-season	Mature leaves from last flush of growth on non-fruiting terminals	30-40
Orange, Grapefruit	Mid-season	Spring cycle leaves, 4 to 7 month old from non-fruiting terminals	25-30
Pecan	6-8 Weeks after bloom	Leaves from terminal shoots, taking the pair from the middle of the leaf	30-45
Raspberry	Mid-season	Take youngest mature leaves on laterals of primo canes	25-40
Strawberry	Mid-season	Youngest fully expanded mature leaves	50-70
Walnut	6-8 weeks after bloom	Middle leaflet pairs from last mature shoots	30-40
Beans	Seedling stage or	Entire above ground portion	25-30
	Prior to or during initial flowering	Two or three mature leaves at the top of the plant	25-30
Cabbage, etc. (head crops) of whorl	Before heading	First mature leaves from center	10-20
Celery	Mid-growth	Youngest mature leaf	30-50
Cucumber	Before fruit set	Mature leaves near base of main stem	20-30
Leaf Crops (lettuce, spinach, etc.)	Mid-growth	Youngest mature leaf	30-50
Melons	Prior to fruit set	Mature leaves near base of main stem	20-30
Peas	Before or during initial flowering	Leaves from the third node down from the top of the plant	30-50
Potato	Before or during early bloom	Third to sixth leaf from growing tip eliminate tip leaflet	20-30
Root Crops (carrots, beets, onions, etc.)	After 8 leaf fern	Center mature leaves	25-35
Sweet corn	Before tasselling or	The entire fully mature leaf below the whorl	20-25
	At tasselling	The entire leaf at the ear node	20-25
Tomato	Before or during	Third or fourth leaf from growing tip early bloom stage	20-25

POSSIBLE CAUSES FOR PLANT NUTRIENT LEVELS ABOVE OR BELOW THE SUFFICIENCY LEVEL

	Above Sufficiency Level	**Below Sufficiency Level**
NITROGEN (N)		
	1) Excessive application of Nitrogen fertilization	1) Inadequate nitrogen fertilization
	2) High rate of nitrification at the time.	2) Low nitrification rate or perhaps denitrification
	3) Shortage of other elements	3) Low soil phosphorus level
PHOSPHORUS (P)		
	1) High soil phosphorus excessive application of phosphate fertilizers	1) Low soil phosphorus level or inadequate phosphorus fertilization
		2) Wet soils
	high soil pH (7.5)	3) Low soil pH (5.5) or
		4) Low organic activity in soil
POTASSIUM (K)		
	1) High soil potassium level or excessive application of potassium fertilizers	1) Low soil potassium level or inadequate potassium fertilization for crop needs
SULFUR (S)		
	1) Excessive available soil sulfate level from natural or applied sources	1) Low available soil sulfate level
		2) Excessive available nitrogen in low organic matter soils
		3) Inadequate sulfate fertilization or excessive leaching of sulfates
		4) Low organic activity in soil

	Above Sufficiency Level	Below Sufficiency Level
		2) Excessive nitrogen application
MAGNESIUM (Mg)		
	1) Diseased or dead tissue	1) Low soil magnesium level(can be due to low soil pH, continuous use of high calcium lime on low magnesium soils, or naturally calcareous soils low in Mg.
	2) Poor K availability	2) High soil nitrogen availability
	3) Old plant tissue in sample	3) Low calcium availability
		4) Excess calcium in soil
CALCIUM (Ca)		
	1) Diseased or dead tissue	1) Low soil calcium level (can be due to low soil pH or highly leached low exchange capacity soils)
	2) Old plant tissue in sample	2) Low soil potassium levels in plant tissue.
		3) High soil nitrogen availability
IRON (Fe)		
	1) Reduced soil conditions from very wet or flooded soils	1) High soil pH
	2) Zinc deficiency	2) Excessive zinc,phosphate, copper, or manganese availability
	3) Soil or dust contamination	
MANGANESE (Mn)		
	1) High nitrogen or phosphorus applications on acid, low organic soil	1) Low natural soil manganese content
	2) Low soil pH	2) Low availability due to high soil pH (7.0 or above), high soil moisture, and very low organic matter content.
	3) Soil or dust contamination	
	4) Contamination from certain fungicide sprays	

	Above Sufficiency Level	Below Sufficiency Level
BORON (B)		
	1) Excessive or improper boron fertilization	1) Low soil availability (can be caused by high soilpH or high leached sandy soils, or low organic matter soils)
COPPER (Cu)		
	1) High soil copper content (may be caused by previous year's pesticide sprays or dust now contained in soil)	1) Low soil availability (Associated with high soil pH, high organic matter content, high concentrations of iron and manganese, and highly leached soils)
ZINC (Zn)		
	1) Naturally high soil zinc	1) Low soil zinc content
	2) Contamination from brass	2) Low soil availability (due to leached soils, soil pH, high phosphorus, areas with low matter content certain muck soils)
MOLYBDENUM (Mo)		
	1) High soil pH	1) Low soil pH (5.5)
	2) Potassium deficiency in some cases	2) High phosphate levels
SODIUM (Na)		
	1) High sodium content in soils	1) Seldom, if ever, deficient except possibly for sugar beets or spinach
ALUMINUM (Al)		
	1) Low soil pH	1) Cannot be deficient Not an essential element
	2) Reduced conditions associated with wet or flooded soils	
	3) Soil or dust contamination	

GUIDE AND CONSIDERATIONS FOR INTERPRETING PLANT ANALYSIS

1) The timeing of sampling as related to the stage of growth (i.e. young, early bloom, seed set, mature) and character of growth (i.e. slow, normal, rapid,) should be known and considered when interpreting a plant analysis. The element content of a particular plant part can change considerably through the life cycle of most plants.

2) Plants can develop unusual nutrient element contents due to periods of unusually wet or dry soil conditions causing very low availability of some essential plant food elements and excessive availability of other essential and non-essential elements. Other environmental factors such as temperature, light period and intensity should also be considered.

3) Crop variety also bears consideration. Different varities have different inherited characteristics and abilities to accumulate and utilize the essential plant food elements. For example, corn leaves from different varieties grown on the same soil and sampled at initial silk stage have shown nearly 50% deviation of some of the major element contents and more than 100% deviation of certain minor element contents.

4) The uptake by roots and the mobility of plant food elements between plant parts, in association with the rate of plant growth will affect the concentration of these elements in plant tissue. Element absorption and plant growth closely parallel each other during most of the vegetative growth period under normal growing conditions. But during very early growth and after seed set and development, the normal growth rate is interrupted and element concentration or dilution can occur. Nitrogen, phosphorus, potassium, are mobile in plants and will move from older tissue to newly developing parts in order to supply the amount needed for growth.

5) The application of N-P-K fertilizers or limestone to soils can significantly alter the concentration of more than one element in plant tissues and may lead to deficiencies or toxicities of other elements.

PLANT ANALYSIS FOR NUTRIENT LEVELS FOR CROPS

SOME AVERAGE VALUES AND CRITICAL LEVELS FOR VARIOUS COMMERCIAL CROPS ARE LISTED ON THE FOLLOWING PAGES. THESE VALUES SHOULD BE USED AS A REFERENCE ONLY AND SHOULD BY NO MEANS BE CONSIDERED ABSOLUTE OR CONCLUSIVE.

DESCRIPTION	PERCENT						PARTS PER MILLION				
	N	P	K	Ca	Mg	S	Fe	Zn	Mn	Cu	B
ALFALFA											
Stage 1	4.60	.46	3.68	3.68	.46	.46	95	36	60	13	44
2	4.60	.40	2.70	1.80	.42	.36	Same for all stages				
3	4.20	.42	2.70	2.20	.42	.36					
4	3.80	.40	2.70	2.20	.42	.36					
ALMONDS											
Stage 1	3.20	.32	2.56	2.56	.32	.32	130	37	60	16	42
2	3.80	.38	3.04	3.04	.38	.38	Same for all stages				
3	3.40	.34	3.04	3.04	.34	.34					
4	3.00	.30	3.00	3.00	.30	.30					
APPLES											
Stage 1	2.10	.21	1.68	1.68	.21	.21	105	25	65	12	31
2	2.50	.25	2.00	2.00	.25	.25	Same for all stages				
3	2.20	.22	2.20	2.20	.22	.22					
4	2.00	.20	1.60	1.60	.20	.20					
APRICOTS											
Stage 1	2.60	.26	2.00	2.00	.30	.30	110	35	70	18	38
2	3.10	.26	2.00	2.00	.30	.30	Same for all stages				
3	2.90	.30	2.40	2.40	.30	.30					
4	2.70	.30	2.40	2.40	.25	.30					
ASPARAGUS											
Stage 1	3.60	.38	3.04	3.04	.38	.38	150	35	60	50	35
2	4.60	.46	3.68	3.68	.46	.46	Same for all stages				
3	4.60	.46	4.60	4.60	.46	.46					
BARLEY (lincluding oats)											
Stage 1	3.40	.34	2.72	2.72	.34	.34	55	30	31	12	19
2	3.80	.38	3.04	3.04	.38	.38	Same for all stages				
3	3.20	.32	2.56	2.56	.32	.32					
4	2.80	.28	2.24	2.24	.28	.28					
BEANS DRY (incl. white kidney, light kidney, dark red kidney, green beans)											
Stage 1	4.20	.42	3.36	3.36	.42	.42	135	36	83	14	42
2	4.20	.42	3.36	3.36	.42	.42	Same for all stages				
3	4.20	.42	3.36	3.36	.42	.42					
4	3.80	.38	3.04	3.04	.38	.38					

DESCRIPTION	PERCENT						PARTS PER MILLION				
	N	P	K	Ca	Mg	S	Fe	Zn	Mn	Cu	B
CANTALOUPE											
Stage 1	**3.80**	**.38**	**3.04**	**3.04**	**.38**	**.38**	**118**	**53**	**91**	**14**	**32**
2	**4.20**	**.42**	**3.36**	**3.36**	**.42**	**.42**	Same for all stages				
3	**4.00**	**.40**	**4.00**	**4.00**	**.40**	**.40**					
CARROTS											
Stage 1	**3.20**	**.32**	**2.56**	**2.56**	**.32**	**.32**	**84**	**50**	**46**	**27**	**36**
2	**3.20**	**.32**	**2.56**	**2.56**	**.32**	**.32**	Same for all stages				
3	**3.20**	**.32**	**3.20**	**3.20**	**.32**	**.32**					
CAULIFLOWER											
Stage 1	**3.70**	**.37**	**3.00**	**2.50**	**.40**	**.35**	**135**	**40**	**50**	**14**	**30**
2	**3.70**	**.37**	**2.96**	**2.96**	**.37**	**.37**	Same for all stages				
3	**4.00**	**.40**	**3.20**	**3.20**	**.40**	**.40**					
CELERY											
Stage 1	**3.80**	**.38**	**3.04**	**3.04**	**.36**	**.36**	**95**	**36**	**67**	**11**	**34**
2	**3.80**	**.38**	**3.04**	**3.04**	**.38**	**.38**	Same for all stages				
3	**3.80**	**.38**	**3.04**	**3.04**	**.38**	**.38**					
CHERRY											
Stage 1	**2.80**	**.28**	**2.24**	**2.24**	**.28**	**.28**	**75**	**32**	**52**	**19**	**32**
2	**3.30**	**.33**	**2.64**	**2.64**	**.33**	**.33**	Same for all stages				
3	**2.80**	**.28**	**2.24**	**2.24**	**.28**	**.28**					
4	**3.00**	**.28**	**2.24**	**2.24**	**.30**	**.30**					
CHILI											
Stage 1	**3.80**	**.38**	**3.04**	**3.04**	**.38**	**.38**	**220**	**40**	**115**	**18**	**45**
2	**4.20**	**.42**	**3.36**	**3.36**	**.42**	**.42**	Same for all stages				
3	**3.80**	**.38**	**3.04**	**3.04**	**.38**	**.38**					
CITRUS (incl. lemons, grapefruit, tangerines)											
Stage 1	**2.40**	**.24**	**1.92**	**1.92**	**.24**	**.24**	**85**	**34**	**45**	**12**	**36**
2	**2.80**	**.28**	**2.24**	**2.24**	**.28**	**.28**	Same for all stages				
3	**2.60**	**.26**	**2.60**	**2.60**	**.26**	**.26**					
4	**2.60**	**.26**	**2.60**	**2.60**	**.26**	**.26**					
CORN (incl. sweet corn, baby corn)											
Stage 1	**3.20**	**.32**	**2.56**	**2.56**	**.32**	**.32**	**95**	**33**	**60**	**12**	**13**
2	**3.80**	**.38**	**3.04**	**3.04**	**.38**	**.38**	Same for all stages				
3	**3.80**	**.38**	**2.40**	**2.40**	**.38**	**.38**					
4	**2.00**	**.20**	**2.60**	**2.60**	**.20**	**.20**					
COSTAL BERMUDA GRASS											
Stage 1	**3.00**	**.30**	**2.40**	**2.40**	**.30**	**.30**	**55**	**23**	**65**	**10**	**7**
2	**3.00**	**.30**	**2.40**	**2.40**	**.30**	**.30**	Same for all stages				
3	**3.00**	**.30**	**2.40**	**2.40**	**.30**	**.30**					
4	**2.80**	**.28**	**2.24**	**2.24**	**.30**	**.30**					

DESCRIPTION	PERCENT						PARTS PER MILLION				
	N	P	K	Ca	Mg	S	Fe	Zn	Mn	Cu	B
COTTON (short staple)											
Stage 1	**4.00**	**.40**	**3.20**	**3.20**	**.40**	**.40**	**104**	**41**	**48**	**19**	**62**
2	**4.60**	**.46**	**3.68**	**3.68**	**.46**	**.46**	Same for all stages				
3	**3.80**	**.38**	**3.04**	**3.04**	**.38**	**.38**					
4	**3.00**	**.30**	**2.40**	**2.40**	**.30**	**.30**					
COTTON (long staple)											
Stage 1	**3.60**	**.36**	**2.88**	**2.88**	**.36**	**.36**	**104**	**41**	**48**	**19**	**62**
2	**3.60**	**.36**	**2.88**	**2.88**	**.36**	**.36**	Same for all stages				
3	**3.20**	**.32**	**2.56**	**2.56**	**.32**	**.32**					
4	**3.00**	**.30**	**2.40**	**2.40**	**.30**	**.30**					
CUCUMBERS											
Stage 1	**4.00**	**.40**	**3.20**	**3.20**	**.40**	**.40**	**300**	**48**	**85**	**16**	**45**
2	**4.40**	**.44**	**3.52**	**3.52**	**.44**	**.44**	Same for all stages				
3	**4.00**	**.40**	**3.20**	**3.20**	**.40**	**.40**					
4	**3.60**	**.36**	**3.20**	**3.20**	**.40**	**.40**					
GARLIC											
Stage 1	**3.80**	**.38**	**3.04**	**3.04**	**.38**	**.38**	**100**	**50**	**80**	**15**	**25**
2	**4.40**	**.44**	**3.52**	**3.52**	**.44**	**.44**	Same for all stages				
3	**3.80**	**.38**	**3.04**	**3.04**	**.38**	**.38**					
4	**3.60**	**.36**	**2.88**	**2.88**	**.36**	**.36**					
GRAIN SORGHUM											
Stage 1	**3.40**	**.34**	**2.72**	**2.72**	**.34**	**.34**	**80**	**30**	**50**	**90**	**12**
2	**3.90**	**.39**	**3.12**	**3.12**	**.39**	**.39**	Same for all stages				
3	**3.40**	**.34**	**2.72**	**2.72**	**.34**	**.34**					
4	**2.70**	**.27**	**2.16**	**2.16**	**.27**	**.27**					
GRAPES (lincl. Thompson, Perlette, Red Flames))											
Stage 1	**2.70**	**.27**	**2.20**	**2.20**	**.27**	**.27**	**75**	**36**	**70**	**12**	**31**
2	**3.00**	**.30**	**2.40**	**2.40**	**.30**	**.30**	Same for all stages				
3	**2.80**	**.28**	**2.60**	**2.60**	**.28**	**.28**					
4	**2.40**	**.24**	**2.40**	**.2.40**	**.24**	**.24**					
JOJOBA											
Stage 1	**1.50**	**.15**	**1.20**	**1.20**	**.15**	**.15**	**97**	**37**	**29**	**11**	**28**
2	**2.00**	**.20**	**1.60**	**1.60**	**.20**	**.20**	Same for all stages				
3	**1.80**	**.18**	**1.44**	**1.44**	**.18**	**.18**					
4	**1.80**	**.18**	**1.44**	**1.44**	**.18**	**.18**					
LETTUCE											
Stage 1	**4.50**	**.45**	**3.60**	**3.60**	**.45**	**.45**	**80**	**45**	**120**	**14**	**32**
2	**4.60**	**.46**	**3.68**	**2.50**	**.46**	**.46**	Same for all stages				
MINT (incl. spearmint)											
Stage 1	**3.90**	**.39**	**3.12**	**3.12**	**.39**	**.39**	**140**	**42**	**83**	**20**	**25**
2	**4.30**	**.43**	**3.44**	**3.44**	**.43**	**.43**	Same for all stages				
3	**4.30**	**.43**	**3.44**	**3.44**	**.43**	**.43**					
4	**3.90**	**.39**	**3.12**	**3.12**	**.39**	**.39**					

DESCRIPTION	PERCENT						PARTS PER MILLION				
	N	P	K	Ca	Mg	S	Fe	Zn	Mn	Cu	B
OATS											
STAGE 1	3.00	.33	1.70	1.00	.25	.35	55	30	31	12	19
2	3.00	.33	1.70	1.00	.25	.35	Same for all stages				
3	3.00	.33	1.70	1.00	.25	.35					
4	2.50	.33	1.70	1.00	.25	.35					
ONIONS											
Stage 1	3.40	.34	2.72	2.72	.34	.34	90	55	75	16	27
2	3.80	.38	3.04	3.04	.38	.38	Same for all stages				
3	3.40	.34	2.72	2.72	.34	.34					
4	3.10	.31	3.10	3.10	.31	.31					
ORANGES											
Stage 1	2.60	.26	2.08	2.08	.26	.26	130	60	120	15	54
2	2.60	.26	2.08	2.08	.26	.26	Same for all stages				
3	2.60	.26	2.08	2.08	.26	.26					
4	2.60	.26	2.08	2.08	.26	.26					
PEACH (incl. Nectarine)											
Stage 1	3.80	.38	3.04	3.04	.38	.38	130	40	55	12	30
2	3.60	.36	2.88	2.88	.36	.36	Same for all stages				
3	3.80	.38	3.04	3.04	.38	.38					
4	3.40	.34	2.72	2.72	.34	.34					
PEANUTS											
Stage 1	3.20	.32	2.56	2.56	.32	.32	150	70	50	30	60
2	4.00	.40	3.20	3.20	.40	.40	Same for all stages				
3	3.80	.38	3.04	3.04	.38	.38					
4	3.40	.34	2.72	2.72	.34	.34					
PEAR											
Stage 1	3.00	.30	2.40	2.40	.30	.30	89	34	52	13	32
2	3.30	.33	2.64	2.64	.33	.33	Same for all stages				
3	2.80	.28	2.24	2.24	.28	.28					
4	3.00	.30	2.40	2.40	.30	.30					
PEAS											
Stage 1	3.50	.35	3.00	2.50	.40	.25	150	70	50	30	60
2	3.50	.35	3.00	2.50	.40	.25	Same for all stages				
3	3.50	.35	3.00	2.50	.40	.25					
4	2.80	.35	3.00	2.50	.40	.25					
PECAN											
Stage 1	2.60	.26	2.08	2.08	.26	.26	100	48	115	25	55
2	3.00	.30	2.40	2.40	.30	.30	Same for all stages				
3	2.40	.24	1.92	1.92	.24	.24					
4	3.00	.30	2.40	2.40	.30	.30					
PEPPERS											
Stage 1	4.40	.44	3.52	3.52	.44	.44	245	43	115	17	46
2	4.40	.44	3.52	3.52	.44	.44	Same for all stages				
3	4.40	.44	3.52	3.52	.44	.44					
4	3.80	.38	3.52	3.52	.38	.38					

DESCRIPTION	PERCENT						PARTS PER MILLION				
	N	P	K	Ca	Mg	S	Fe	Zn	Mn	Cu	B
PISTACHIO											
Stage 1	2.80	.28	2.24	2.24	.28	.28	89	32	60	11	48
2	3.30	.33	2.64	2.64	.33	.33	Same for all stages				
3	3.10	.31	2.48	2.48	.31	.31					
4	3.00	.30	2.40	2.40	.30	.30					
PLUM & PRUNE											
Sage 1	3.00	.30	2.40	2.40	.30	.30	110	40	60	15	30
2	3.40	.34	2.72	2.72	.34	.34	Same for all stages				
3	2.80	.28	2.24	2.24	.28	.28					
4	3.00	.30	2.40	2.40	.30	.30					
POTATOES											
Stage 1	5.40	.54	4.32	4.32	.54	.54	135	50	120	18	35
2	6.00	.60	4.80	4.80	.60	.60	Same for all stages				
3	4.90	.49	4.80	4.80	.54	.54					
4	4.00	.40	4.00	4.00	.40	.40					
RADISHES											
Stage 1	3.20	.30	2.40	2.0	.30	.30	100	40	70	15	25
2	3.20	.30	2.40	2.00	.30	.30	Same for all stages				
3	3.60	.32	2.60	2.4	.34	.30					
4	2.80	.30	2.40	2.40	.30	.30					
RICE											
Stage 1	2.80	.28	2.24	2.24	.28	.28	117	42	52	10	35
2	3.60	.36	2.88	2.88	.36	.36	Same for all stages				
3	3.30	.33	2.90	2.90	.33	.33					
4	2.80	.28	2.80	2.80	.28	.28					
SOYBEAN											
Stage 1	4.40	.44	3.52	3.52	.44	.44	95	39	58	13	41
2	5.20	.52	4.16	4.16	.52	.52	Same for all stages				
3	5.20	.52	4.16	4.16	.52	.52					
4	4.40	.44	.3.52	3.52	.44	.44					
SUGAR BEETS											
Stage 1	4.00	.40	3.20	3.20	.40	.40	115	48	90	15	40
2	4.40	.44	3.52	3.52	.44	.44	Same for all stages				
3	4.20	.42	3.52	3.52	.42	.42					
4	3.20	.32	2.56	2.56	.32	.32					
SQUASH											
Stage 1	3.60	.36	2.88	2.88	.36	.36	180	48	90	15	40
2	4.00	.40	3.20	3.20	.40	.40	Same for all stages				
3	3.80	.38	3.04	3.04	.38	.38					
4	3.40	.34	2.72	2.72	.34	.34					
STRAWBERRY											
Stage 1	3.50	.35	2.80	2.80	.35	.35	155	53	90	14	30
2	3.50	.35	2.80	2.80	.35	.35	Same for all stages				
3	3.70	.37	2.96	2.96	.37	.37					
4	3.50	.35	2.80	2.80	.35	.35					

DESCRIPTION	PERCENT						PARTS PER MILLION				
	N	P	K	Ca	Mg	S	Fe	Zn	Mn	Cu	B
TANGERINES											
Stage 1	**2.60**	**.35**	**2.40**	**3.90**	**.38**	**.28**	**85**	**34**	**45**	**12**	**36**
	2.60	**.35**	**2.40**	**3.90**	**.38**	**.28**	Same for all stages				
	2.60	**.35**	**2.40**	**3.90**	**.38**	**.28**					
	2.60	**.35**	**2.40**	**3.90**	**.38**	**.28**					
TOMATOES											
Stage 1	**4.20**	**.42**	**3.36**	**3.36**	**.42**	**.42**	**140**	**40**	**145**	**20**	**60**
2	**4.60**	**.46**	**3.68**	**3.68**	**.46**	**.46**	Same for all stages				
3	**4.20**	**.42**	**3.68**	**3.68**	**.42**	**.42**					
4	**3.20**	**.32**	**3.20**	**3.20**	**.32**	**.32**					
WATERMELON											
Stage 1	**4.20**	**.42**	**3.36**	**3.36**	**.42**	**.42**	**140**	**48**	**90**	**16**	**45**
2	**4.20**	**.42**	**3.36**	**3.36**	**.42**	**.42**	Same for all stages				
3	**4.20**	**.42**	**3.36**	**3.36**	**.42**	**.42**					
4	**3.80**	**.38**	**3.36**	**3.36**	**.42**	**.42**					
WHEAT											
Stage 1	**4.00**	**.40**	**3.20**	**3.20**	**.40**	**.40**	**63**	**36**	**33**	**10**	**27**
2	**4.50**	**.45**	**3.60**	**3.60**	**.45**	**.45**	Same for all stages				
3	**4.00**	**.40**	**3.60**	**3.60**	**.45**	**.45**					
4	**3.20**	**.32**	**2.56**	**2.56**	**.32**	**.32**					