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# SAP TESTING OF NITRATE NITROGEN IN TOMATO

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**ABSTRACT**

**The usefulness of conventional tissue testing techniques is limited for monitoring and adjusting the nitrogen (N) status of rapidly growing crops, such as many vegetables, because of the frequent unavailability of sufficiently quick and reliable test results. The nitrate N status of *Lycopersicon esculentum* 'Celebrity' was monitored in a greenhouse study using "Merkoquant" quick-test nitrate strips to determine the effects of plant-to-plant variation and variation in leaf position and time of day on the levels of nitrate N detectable in petiole sap. Nitrate N levels decreased from 2800 ppm in 28-day-old plants to below 400 ppm in plants older than 68 days. Sap nitrate N concentrations were equal in the top, middle, and bottom of the canopy of 28-day-old plants, but decreased more rapidly in the top of the canopy as the plants developed. Tissue analysis results and sap test results concurred in showing that N availability had been growth limiting. No differences in sap nitrate concentrations were detected between 10 a.m., 12 p.m., and 2 p.m.**

**RESUMEN**

**La utilidad de técnicas convencionales para analizar tejidos de plantas para vigilar y ajustir el nivel de nitrógeno en cultivos de creciminento rápido, tales como muchas hortalizas, es limitada debido a la frequente indisponibilidad de resultados suficientes rápidos y seguros. El nivel de nitrógeno en forma de nitrato de *Lycopersicon esculentum* 'Celebrity' fue vigilado en un estudio de invernadero usando laminas de nitrato de ensayo rápido "Merkoquant" para determinar los efectos de variación entre plantas y la variación en posición de hoj y tiempo del día sobre los niveles de nitrato encontrados en la savia del peciolo. Los niveles de nitrato bajaron de 2800 ppm en plantas de 28 días de edad a menos de 400 ppm en plantas mayores de 68 días de edad. Las concentraciones de nitrato en la savia eran iguales en la parte superior, la parte intermediana y la parte mas baja de plantas de 28 dias de edad, pero decrecieron mas rapido en la parte superior de las plantas mientras éstas se desarrollaron. Resultados del análisis de tejidos y de la savia concurrieron que la disponibilidad de nitrógeno limitaba el crecimiento. No se notó ninguna diferencia en la concentración de nitrato en la savia entre 10 a.m., 12 p.m. y 2 p.m.**

Keywords: Nitrate-N; N-fertilizers; Sap tests; Tomato

Nitrogen is one of the most important nutrients for crop production. It is also one of the most difficult to manage because both N supply in the soil and N demand by the crop are sensitive to environmental influences, including rainfall, temperature, and light intensity, over which the grower has little or no control. These factors can cause significant changes in crop N status and consequently can influence crop yields unpredictably.

Growers may overfertilize to reduce the risk of N deficiency developing in their crops, but this approach is not without its drawbacks. Besides wasting costly fertilizer, excessive N applications can result in poor stand establishment, reductions in crop quality, and losses in crop yield (6).

Plant tissue analysis is a useful tool for determining whether N supply to a crop is keeping pace with N demand by the crop. Nitrate N is a particularly sensitive indicator of crop N status, varying greatly and rapidly between plants adequately and inadequately supplied with N. However, conventional tissue testing procedures are of limited usefulness for the purpose of monitoring and making adjustments to current crop N status because of the time delays and expenses involved in obtaining tissue test results from testing laboratories.

Rapid, accurate, and inexpensive nitrate testing has recently begun to appear feasible using "Merkoquant" test strips. The cost of a nitrate analysis is only about U.S. $0.20. The nitrate determination can be made in 2 minutes or less. Results of limited field testing of horticultural crops with these nitrate strips have yielded nitrate values broadly comparable to those obtained with more elaborate laboratory procedures (4). There would seem to be great potential for using test-strip methodologies to improve N fertilization practices throughout the tropics in areas not served adequately by tissue testing laboratories.

A number of factors appear to influence the concentration of nitrate found in plants, including leaf position (1, 2, 7) and time of day (3, 7). Plant-to-plant variability also can be considerable (7). The impact of these factors needs to be characterized in detail to facilitate the development of effective interpretive guidelines for using sap nitrate testing in a monitoring role. The purpose of this experiment was to determine the significance of plant-to-plant variation and variation in leaf position and time of day on paper-strip analyses of nitrate in the petiole sap of greenhouse-grown tomato plants.

## Materials and methods

Eighty 'Celebrity' tomato plants were grown in a greenhouse for 88 days commencing in October 1984 in pots containing 0.015 $m^3$ of 2 peat: 1 perlite: 6 vermiculite (by volume) amended with 4.8 kg $m^{-3}$ dolomite, 0.11 kg $m^{-3}$ gypsum, 0.7 kg $m^{-3}$ Micromax slow release micronutrients (Sierra Chemical Co., Milipitas, California), and 1.1 kg $m^{-3}$ concentrated superphosphate (ON-20P-OK). The pots received 20 ppm N and 100 ppm K continuously during 3 irrigations of 2 liters each per day fully delivered 1 hour before predetermined petiole sap sampling times of 10 a.m., 12 p.m., and 2 p.m. Air temperature and an estimate of the average percent of cloud cover throughout the day were recorded daily. Photosynthetically active radiation (PAR) was measured periodically on sap sampling days.

Sap nitrate sampling at 10 day intervals began 28 days from seeding. At 12 p.m. each sampling day, 3 groups of 10 randomly chosen plants each were selected. Petioles were excised from the top of the canopy of the first group of plants (youngest fully unfurled leaf), from the middle of the canopy of the second group of plants (youngest fully expanded leaf), and from the bottom of the canopy of the third group of plants (lowest healthy leaf). Ten petioles also were excised from the top of the canopy of 10 randomly selected plants at 10 a.m. and 2 p.m. Sap was rolled out of the petioles using a thick pen barrel and immediately applied to the nitrate-sensitive area of a Merkoquant test strip. Nitrate N concentration was then determined by comparing the color developed in 2 minutes on the strip with the accompanying chart of color standards. Concentrations above the range of the standards were determined by timing color development to the darkest intensity on the standardizing chart (114 ppm) and using an equation reported to describe this relationship (7) as follows:

$$NO_3\text{-}N\ [ppm] = 10^{4.25-1.085 \log 10^{t\ [sec]}}$$

On each sampling day, 5 plants were harvested and analyzed for dry weight and N content of vegetative and reproductive structures.

**Results and discussion**

Mean daily maximum and minimum air temperatures in the greenhouse during the experiment were approximately 30 °C and 20 °C respectively. Photosynthetically active radiation during clear periods was about 1100 µmol $m^{-2}$ $s^{-1}$, but only about 300 umol $m^{-2}$ $sec^{-1}$ when cloudy. Skies were clear about 75% of the time during most of the experiment, but the frequency of clear conditions dropped below 50% during a period of cloudy weather between days 68 and 78.

Total dry weight accumulation increased at a slightly accelerating rate throughout the experiment (Fig. 1). The rate of vegetative and total growth was noticeably reduced during the cloudy period between days 68 and 78. The rate of increase in flowering and

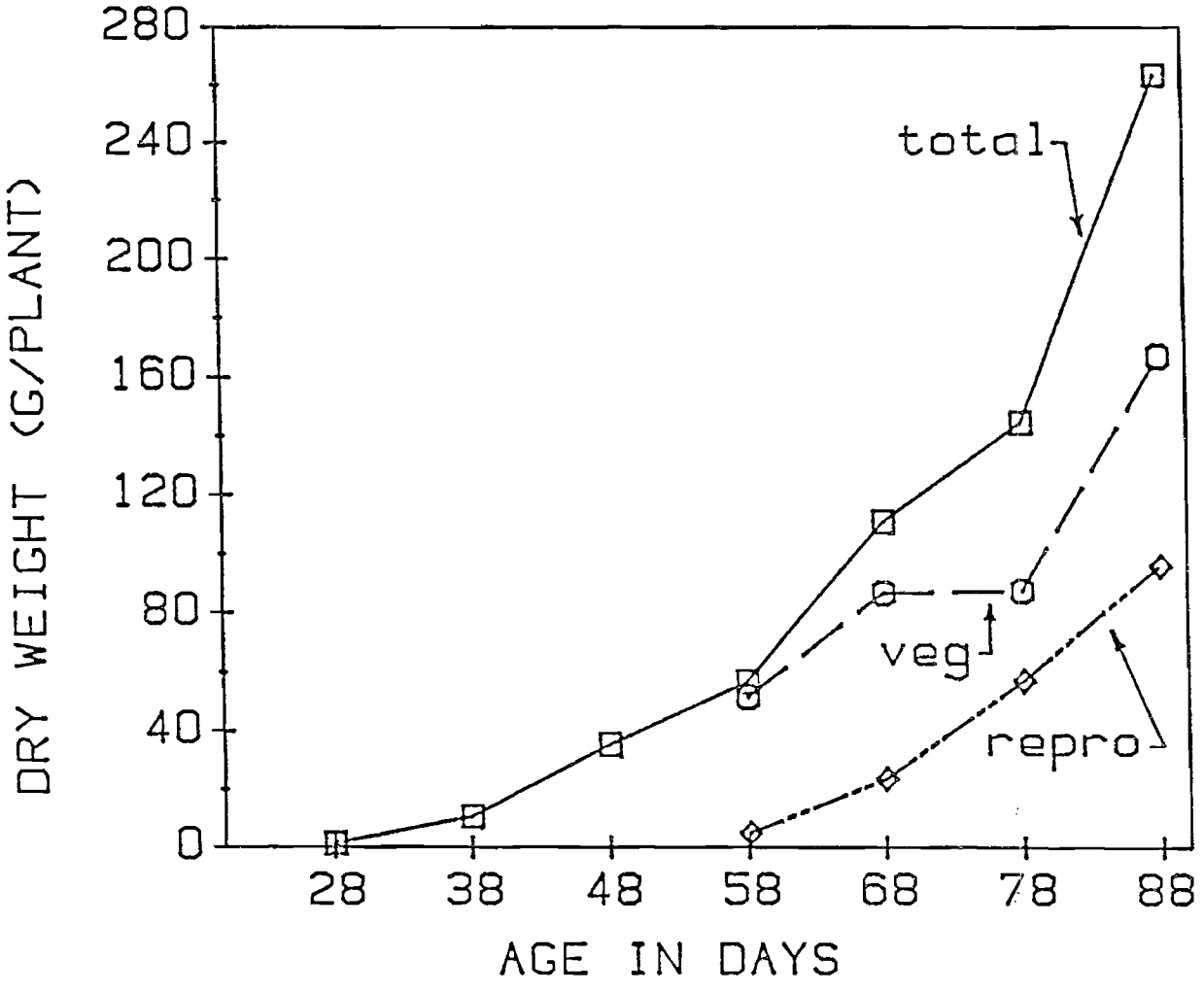



Fig. 1. Dry weight accumulation of 'Celebrity' tomatoes grown in a greenhouse at UH - Manoa between October 1984 and January 1985.

fruiting structures was unaffected. Patterns of N accumulation in the crop closely paralleled patterns of dry weight accumulation (Fig. 2). Total N percentage in the top leaf petioles declined steadily throughout crop development, falling from 4.5% at the start of the sampling period to below 1% by fruit initiation (day 68). This low value at fruiting indicated that a condition of N deficiency had developed during the experiment, despite the deep green and vigorous appearance of the plants. Sap nitrate test results also had indicated the development of N deficiency (Fig. 3). In general, nitrate N levels decreased from about 2800 ppm in 28-day-old plants to below 400 ppm in plants older than 68 days. Recent studies involving nitrate sap testing with field tomatoes indicate that about 1000 ppm nitrate N is desirable in plants of this latter age to produce maximum yields (5). Sap nitrate monitoring would have allowed a quick corrective response to the development of the N deficiency.

Sap nitrate N concentrations were equal in the top, middle, and bottom of the canopy of 28-day-old plants, but decreased more rapidly in the top of the canopy than lower in the canopy as plants developed. The greater sensitivity of upper leaves to N deficiency has been previously noted (1).

Plant-to-plant variability in sap nitrate concentrations in field crops has led to the recommendation that at least 20 plants be sampled and the results averaged to ensure a reliable mean value (7). In this experiment, variability in the 10-plant sample resulted in a LSD between means of 300 ppm (Fig. 3) This LSD would have been adequate to indicate deficiency in the 68-day-old crop based on a critical value of 1000 ppm. It is reasonable to find plant-to-plant variability less of a problem in greenhouse grown crops.

Diurnal fluctuation in nitrate N with peak values around 8 a.m. and 3-fold lower values by 4 p.m. have been reported (3). In this experiment nitrate N concentrations did not vary greatly or consistently between 10 a.m. and 2 p.m. (Fig. 4). Other recent work has failed to corroborate a significant diurnal effect on sap levels over the day, although a low number of replicates may have masked the results (7). Aditional work is needed to determine whether sap testing guidelines require standardization of test time, or whether equally useful information can be obtained throughout the day.

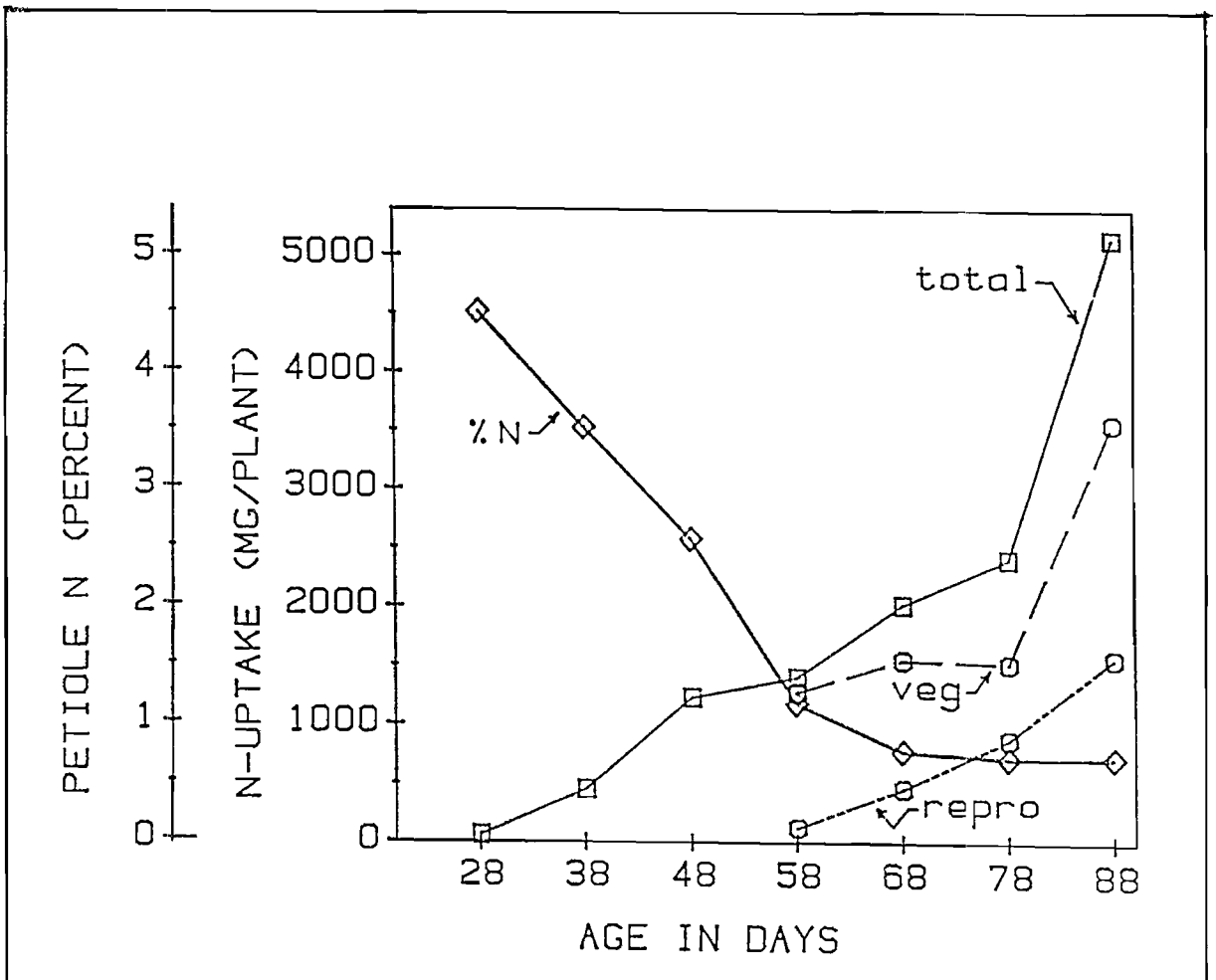
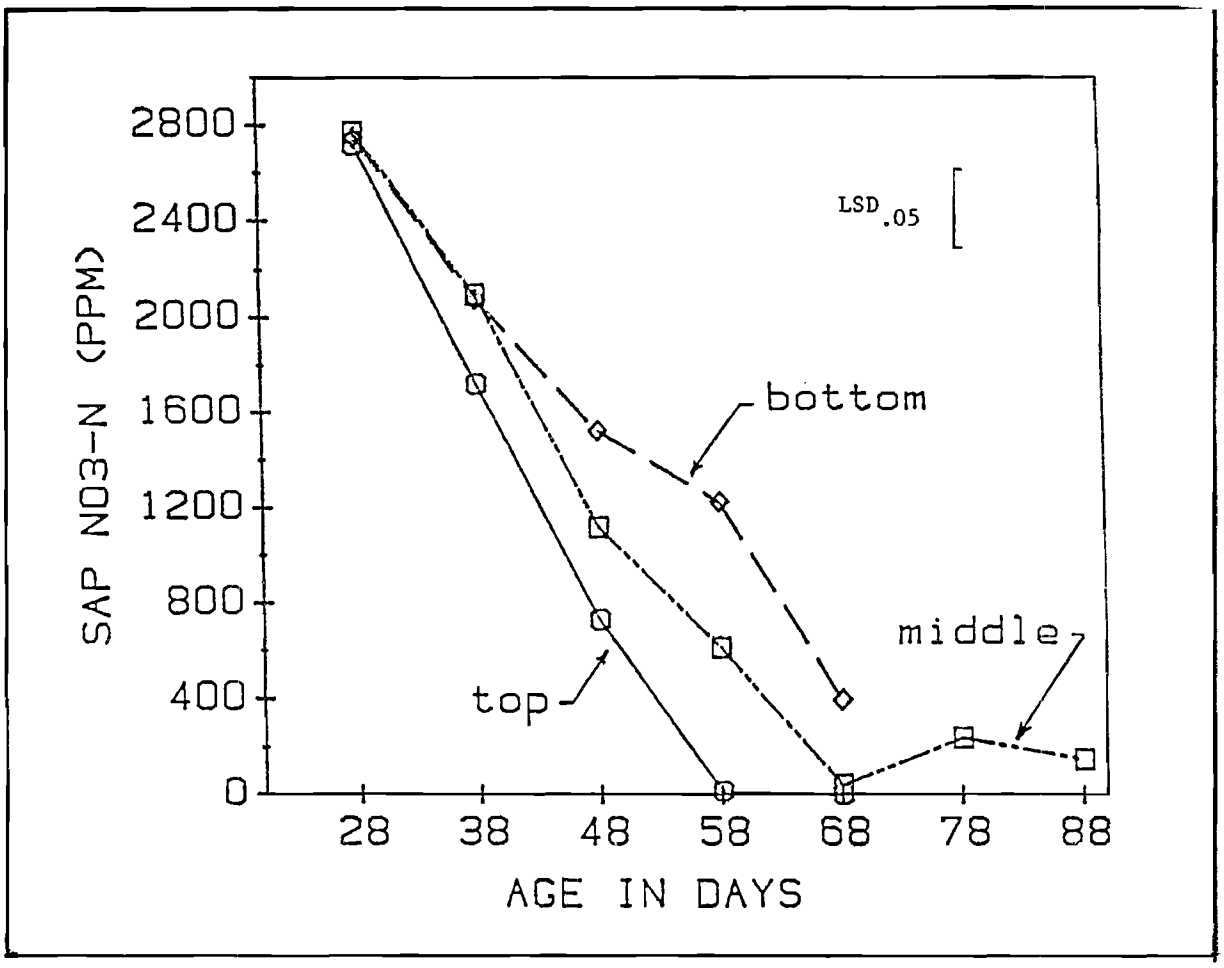



Fig. 2. Nitrogen content of 'Celebrity' tomatoes grown in a greenhouse at UH - Manoa between October 1984 and January 1985.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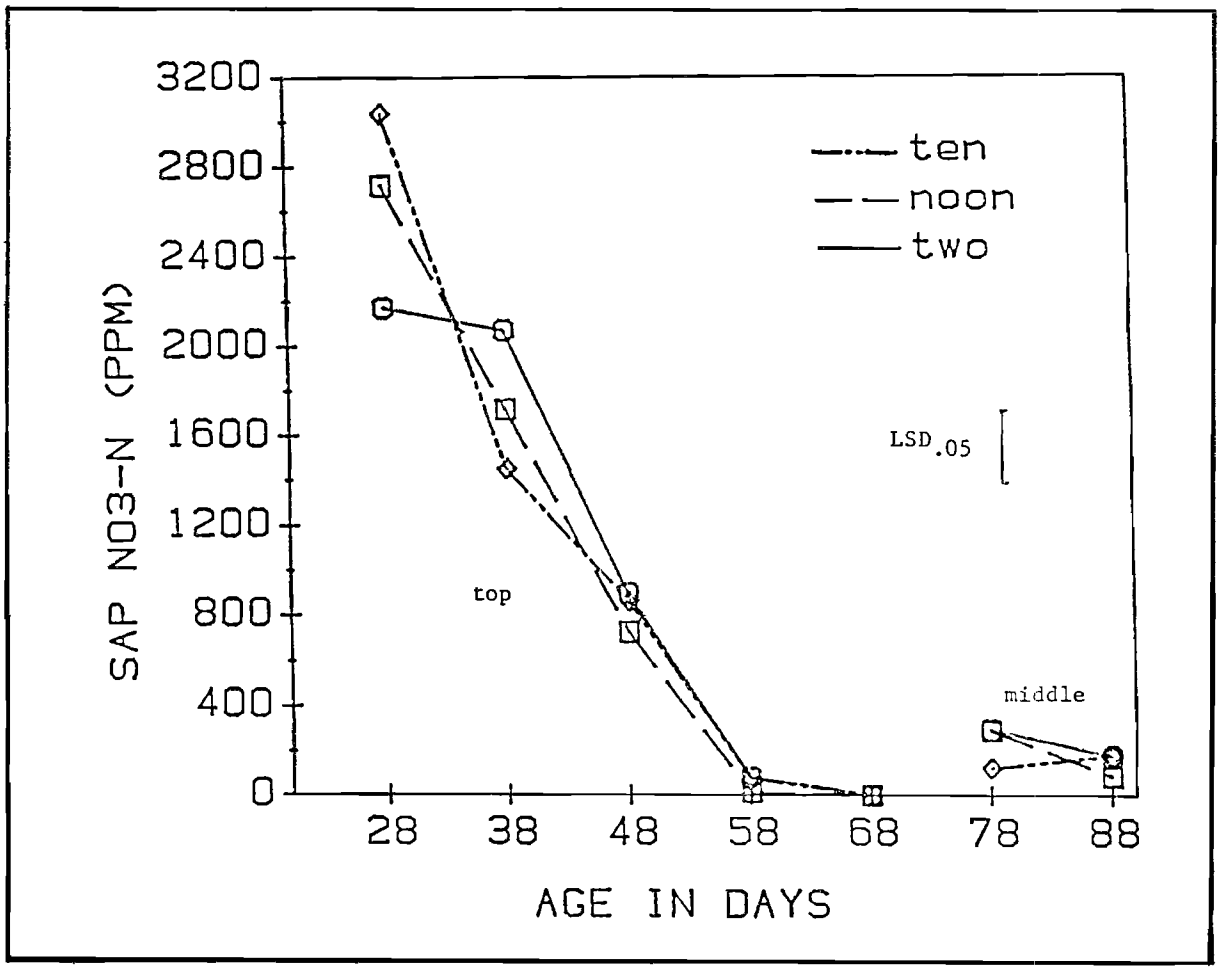
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AGE IN DAYS

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