vineyards where *M. occidentalis* has developed a modest level of Cygon resistance. Unfortunately, no truly selective insecticide is available that is effective against the grape leafhopper, *Erythroneura elegantula* Osborn, but has low toxicity to most field populations of the two beneficial mites. Laboratory-selected strains of *M. occidentalis* are resistant to Sevin, organophosphates, and sulfur, and their release would offer greater flexibility in pesticide use.

The situation is somewhat better with regard to fungicides. Populations of *M. occidentalis* tested in previous studies are tolerant to Bayleton, and the Sevin-resistant strain is cross-resistant to Benlate. Use of these materials to control powdery mildew, *Uncinula necator* (Schw.), could conserve both the predator and the tydeid.

If lower than label rates of Omite are used to assist *M. occidentalis* in controlling spider mites, then this acaricide might be used without excessive detriment to the tydeid populations.

Integrated pest management built around biological control of Pacific spider mites by *M. occidentalis* may have to make pollen available to support populations of the tydeid as alternate prey and include control of insect pests with biological agents or with pesticides that conserve both beneficial mites as key components in the program.

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Lettuce efficiency in using fertilizer nitrogen

Norman C. Welch □ Kent B. Tyler □ David Ririe □ Francis Broadbent

The crop has a low efficiency in using fertilizer nitrogen but needs adequate nitrogen just before harvest to produce heads of acceptable size and color

Head lettuce typically needs an abundant supply of soil nitrogen close to harvest time to attain maximum yield and quality required by the fresh market. The lettuce plant produces two-thirds of its fresh weight during the last 30 percent of its growing period. More than 60 percent of the nutrients are absorbed during this period.

Management of nitrogen fertilizer for maximum nutrient uptake efficiency by this shallow-rooted crop presents a challenge to vegetable growers. In 1980, we conducted a field experiment on a Watsonville loam soil in the Pajaro Valley using ^{15}nitrogen-depleted ammonium sulfate to measure fertilizer uptake efficiency and to distinguish between soil and fertilizer nitrogen utilized by the crop. In the previous year, two lettuce crops had been grown with the same nitrogen rates and the same location of treatments to help deplete the soil nitrogen in the untreated check and low-nitrogen-fertilizer areas.

The variety 'Salinas' was planted on 40-inch beds with two rows per bed on April 24 and sprinkle-irrigated the following day. After seedling emergence and stand establishment, two furrow irrigations were applied using less than 6 inches of water to grow the crop. All plots received 400 pounds of 0-20-20 fertilizer banded into the soil as the beds were listed up for planting. The first nitrogen fertilizer was applied five days before planting. The rates were 0, 60, 120, 180, and 240 pounds per acre in single or split applications. One each of the treatments of 60, 120, and 180 pounds nitrogen also received nitrapyrin, applied at the rate of 1 quart per acre by injection of a solution of one part nitrapyrin to nine parts water onto the dry ammonium sulfate band. In split nitrogen treatments, the second application was banded into the bed after thinning, about six weeks after planting.

Preplant and post-harvest soil samples were taken from each of the 10 treatments and five replications in 1-foot increments to a depth of 3 feet. Leaf midribs sampled at approximately two-week intervals after thinning were analyzed for nitrate nitrogen. Whole-top samples were taken during the season and analyzed for total nitrogen and ratios of isotopic nitrogen. Measurement of the isotopic composition of these forms of nitrogen in whole-top samples permitted calculation of the amount of fertilizer-derived nitrogen present.

The spring lettuce crop was harvested on June 26; a 10-foot length of bed was used to obtain 24 heads, or one carton. Each head was trimmed to a uniform number of wrapper leaves before weighing.

Leaf midrib analyses

Nitrate (NO_3) levels in the midribs provided a basis for differentiating between part of the fertilizer treatments (see table). Nitrate levels in plots receiving no fertilizer nitrogen were significantly lower than in all other treatments for the preheading and cap leaf samples. Midrib nitrate levels for 30 + 30 nitrogen rates were not significantly different from 60-pound nitrogen + nitrapyrin and 120-pound nitrogen rates. Midrib analyses did not effectively separate treatments with acceptable lettuce head weight from those with heads too small for market. Nitrate levels for the treatment producing too-large heads were not significantly different from those in treatments producing desirable head size. Large size is undesirable because of the extra shipping cost and the increased damage to lettuce packed in bulging cartons.

The ability of the lettuce crop to utilize soil nitrogen is clear. Even at the highest application rates, the amount of soil nitrogen in crops exceeded that derived from fertilizers. The crop's efficiency in uptake of applied nitrogen was low, ranging from 12 percent for 180 pounds of nitrogen in a single application to 25 percent for 60 pounds in split application (fig 1). The efficient use of fertilizer nitrogen decreased as rates increased.

The nitrapyrin treatments resulted in significantly greater total nitrogen uptake, as compared with single or split applications (fig. 2). However, nitrapyrin use did not result in a significant increase in uptake of fertilizer nitrogen at comparable rates for split application (fig. 3).

Leaf midrib nitrate nitrogen and yields under various fertilizer nitrogen treatments in spring lettuce

Fertilizer nitrogen*	Leaf nitrate nitrogen†		Spring crop, fresh weight†	
	Preheading	Cap leaf	Harvested	Per 2-doz. heads
lb/acre	*ppm*	*ppm*	*tons/acre*	*lb*
0	5,350 a	3,875 a	23.3 a	31.0 a
30 + 30	7,800 ab	7,965 b	28.0 b	43.0 b
60‡	10,735 bc	8,285 b	32.0 c	48.4 c
120	12,480 c	9,180 b	31.5 c	49.0 c
120‡	10,965 bc	7,870 b	35.7 d	52.4 cd
60 + 60	11,975 c	11,015 c	33.5 c	51.4 cd
180‡	14,325 c	10,690 cd	39.1 e	59.8 e
180	12,765 c	10,855 cd	31.4 c	48.0 c
90 + 90	13,885 c	11,935 cd	35.7 d	55.6 de
120 + 120	11,980 c	12,120 d	36.5 d	54.6 d

* Double figures indicate ammonium sulfate applied in two equal amounts before planting and after thinning about six weeks later; single figures mean all nitrogen applied preplant.
† Figures not connected by common letter are significantly different at 5% level.
‡ Nitrapyrin, 1 quart per acre.

Yield

The plots receiving nitrapyrin outyielded both single and split applications of comparable rates (see table). The single preplant applications without nitrapyrin produced lower yields than split applications.

Plots receiving nitrogen at 60 pounds + nitrapyrin, 60 + 60, 120, 120 + nitrapyrin, and 180 pounds produced lettuce heads of acceptable size and weight for market. Nitrogen rates of 180 + nitrapyrin, 90 + 90, and 120 + 120 pounds produced unacceptably large heads for shipping.

Soil nitrogen

Soil samples before and after each crop suggest that nitrogen is not leached readily in this soil type, because nitrate levels at depths of 1 to 2 feet and 2 to 3 feet were generally about 3 to 7 ppm higher before nitrogen fertilizer was applied in treated plots, than after the crop had been grown. A fairly impervious layer 3 feet below the soil surface helps to form a perched water table in the test area. This situation may have increased the potential of denitrification, since 51 to 70 percent of the labeled nitrogen could not be accounted for after estimating crop removal and nitrogen residual in the soil. In general, there was not a significant difference in soil nitrate ppm between rates for the same depth. Soil nitrate levels increase with soil depth.

Summary

Lettuce has a low efficiency in using fertilizer nitrogen, but the crop needs adequate nitrogen just before harvest to produce heads of acceptable size with dark green color. Nitrapyrin proved beneficial in helping to grow lettuce with reduced rates of ammonium sulfate. Single applications of 60 pounds nitrogen plus nitrapyrin or nitrogen in two split applications of 60 pounds each per acre produced maximum yields, as measured by market-acceptable head weights.

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Single application + nitrapyrin | Split application | Single application

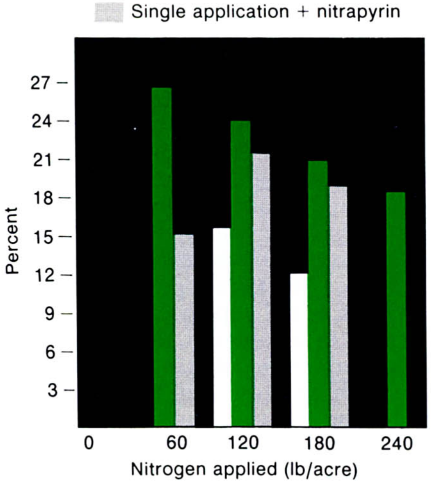

Fig. 1. Lettuce efficiency in uptake of applied nitrogen was low, ranging from 12 to 25 percent.

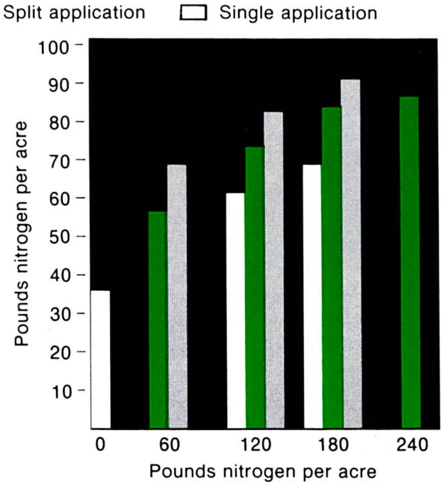

Fig. 2. Nitrapyrin treatments resulted in greater total nitrogen uptake, compared with single or split applications.

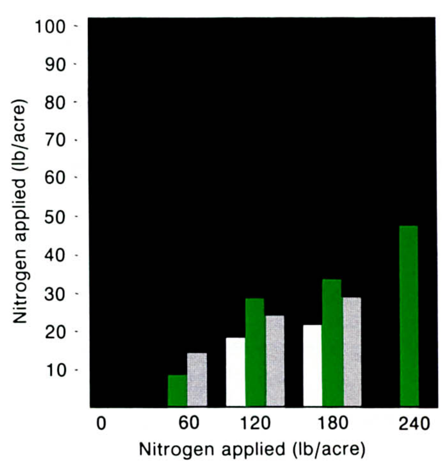

Fig. 3. Nitrapyrin did not significantly increase fertilizer nitrogen uptake at comparable rates for split application.