
Effect and Roles of Nitrogen Supply on Photosynthesis

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Abstract: N deficiency caused a decrease in leaf N content, Chlorophyll a and carbon assimilation of crop plants, resulting in a lower dry matter accumulation. It increases overall plant growth, but the nature of this response depends upon patterns of plant, nitrogen allocation, nutrient that vary throughout the growing season and depend upon canopy position. Decreased photosynthetic capacity is not only associated with direct effects of N deficiency but also with a negative feedback mechanism from the leaf carbohydrate pool. Because of the high requirement of crop plants for elemental N and its numerous important roles in growth and development, N is the mineral element that most often limits crop productivity. Because N mineralization from the soil is normally too low to support desired production levels, soil N levels are typically increased through fertilization. However, the complex cycle of N in the environment causes uncertainty in N fertilizer management, increasing the chances for economic loss and environmental damage. Nitrogen use and productivity of crop plants is also complex, resulting from an interaction of biochemical, physiological, and morphological processes in the plant. Application of N increases N content in the leaves of the soybean plant which increase growth rate, Leaf are, leaf area index and other physiology of the plant during the study.

Keywords: Photosynthesis, Nitrogen, Effect, Growth Rate

1. Introduction

Essential components in the environment are taken up by plants either through their roots or through their leaves (mainly carbon and oxygen). Plants are frequently assumed to be passive in their interactions with their surroundings. However, many plants obviously manage their surroundings to make specific nutrients more easily available, thus this is not always a valid assumption. Based on variances in growth rate, root distribution, phase of development, and nutrient uptake and utilization efficiency, plants adapt their growth rate and metabolism to the availability of ions or nutrient status present.

Metabolic processes based on protein, leading to increases in vegetative and reproductive growth and yield totally dependent upon the adequate supply of nitrogen [1]. It Promotes growth of leaves and stems, gives dark green color and improves quality of foliage and necessary to develop cell proteins and chlorophyll [2]. Nitrogen is the mineral element that plants require in greatest amounts [3]. It is a constituent

of many biomolecules such as proteins, nucleic acids, amino acids, coenzymes, vitamins, and pigments [4]. Therefore, nitrogen deficiency rapidly inhibits plant growth. If such a deficiency persists, most species show [5] (yellowing of the leaves), especially in the older leaves near the base of the plant. Under severe nitrogen deficiency, these leaves become completely yellow or tan and fall off the plant. Younger leaves may not show these symptoms initially because nitrogen can mobilized from older leaves. Thus, a nitrogen-deficient plant may have light green upper leaves and yellow or tan lower leaves. When nitrogen deficiency develops slowly, plants may have markedly slender and often woody stems [6]. This woodiness may be due to a buildup of excess carbohydrates that cannot use in the synthesis of amino acids or other nitrogen compounds. Carbohydrates not used in nitrogen metabolism may also use in anthocyanin synthesis, leading to accumulation of that pigment [7]. This condition revealed as a purple coloration in leaves, petioles, and stems of some nitrogen-deficient plants, such as tomato and certain varieties of corn [8].

To achieve high yields, plants must not only establish

photosynthetic capacity but also continue photosynthesis throughout the grain-filling period. Thus, once established, sufficient N must be available to maintain the photosynthetic apparatus. This role is particularly important because dry matter accumulation in cereal grains is dependent on current photosynthesis. Another important role for N in assuring high productivity of crop plants is establishment of reproductive sink capacity [3]. Sink capacity of a cereal plant is a function of the number and the potential size of grains. Grain number is dependent on the number of ears per unit area, the number of florets per ear, and the proportion of florets that develop into grain, and the potential size of individual grains depends on the number of endosperm cells and starch granules. In either case, reproductive initials, like all growing tissues, characterized by high concentrations of N and high metabolic activities. This need could indicate that sufficient amounts of both C and N assimilates are required for full expression of the genetic potential for initiation and early development of grains.

2. Literature Review

C₄ leaves generally have a lower N content than C₃ leaves because PEP carboxylase is a smaller molecule than rubisco and contains less N. In C₃s, rubisco accounts for around 25% of leaf N. As a result, C₄ plants have greater photosynthesis per unit leaf N and develop more operational leaf area per unit N supply than C₃ plants (Figure 1). Legumes characteristically have large N concentrations in reproductive and vegetative parts. For this reason, their seeds are valuable food for humans, poultry, and swine, and their biomass is valuable fodder for grazing animals. In contrast, the low N content of C₄ grasses is an important reason why they are lower quality fodder for grazing animals than are C₃ grasses. C₄ grasses also have higher contents of indigestible lignin because a greater proportion of their leaf anatomy given to vascular traces.

2.1. Nitrogen Assimilation

To be useful to the plant, inorganic N must be converted into organic forms, typically amino acids, regardless of the form absorbed [6]. Because NH₄ is toxic to plant tissues at low concentrations, it is quickly assimilated in the roots, and the N is translocated as organic compounds. NO₃, on the other hand, can assimilate in the root [9], be stored in the vacuoles of root cells, or be transported to the shoot, where it can be stored or assimilated. Because NO₃ in the vacuole can be made available for assimilation when external sources of N are depleted, nitrate storage and translocation play important roles in N metabolism [10]. However, little is known about the factors that regulate NO₃ entry and exit from the vacuole.

Unlike NH₄, which can be used directly for amino acid synthesis, NO₃ must first be reduced to NH₄ [11]. The reduction of NO₃ to NH₄ is a high-energy process that involves two major partial reactions [12]. The first step involves a two-electron reduction of NO₃ to NO₂, which is

catalyzed by the enzyme nitrate reductase, and the second step involves a six-electron reduction of NO₂ to NH₄, which is catalyzed by nitrite reductase [5]. Because it initiates the reaction and is the logical point of control when NO₃ is available, nitrate reductase is considered the rate-limiting step in the assimilation of NO₃ [3]. Nitrate reductase is also induced by its substrate NO₃; it has a short half-life, and its activity varies with the flux of NO₃ to the sites of induction and assimilation [1]. The reduction of NO₃ by nitrate reductase can occur in either the root or the shoot, and the energy derived is the same in both cases from carbohydrate oxidation [13]. The amount of NO₃ reduced in roots and shoots varies greatly depending on plant species and environmental conditions [8]. Plants are classified into three major groups based on their contribution to total NO₃ reduction by the roots.

- 1) Species with NO₃ reduction in both the root and the shoot,
 - 2) Species with NO₃ reduction in both the root and the shoot, and
 - 3) Species with NO₃ reduction in both the root and the shoot
- Woody plants, perennial herbs, and fast-growing annuals are essentially defined by these three classifications [14].

Although numerous studies have claimed that nitrate reductase is found in the cytosol [5], others have stated that it is found in chloroplasts, microbodies, or the plasmalemma. Higher plants have been found to have two forms of nitrate reductase, which differ in the electron donor. NADH (reduced nicotinamide dinucleotide) [15] is used by one nitrate reductase, while NADH or NADPH is used by another (reduced nicotinamide dinucleotide phosphate). The NADH-specific nitrate reductase is found in all higher plants, and in some species, it is the only form of nitrate reductase. Other plant species, on the other hand, have both a NADH-specific and a NADPH-bispecific nitrate reductase [3]. The NADH-specific nitrate reductase is found in both leaves and roots in several plant species and accounts for the majority of overall nitrate reductase activity, whereas the NADPH-bispecific type is exclusively found in the roots [16]. The reduction of NO₂ to NH₄ can take place in either the root or the shoot, although the cellular location and electron donor differ depending on the reduction site [9]. In the shoot, NO₂ reduction happens in the chloroplast and is related to the photosynthetic light response via decreased ferredoxin as an electron donor [17]. The root nitrite reductase is similar but not identical to the leaf enzyme, (2) the electron donor is a ferredoxin-like protein that is not identical to the leaf protein, and (3) the root ferredoxin is reduced by NADPH and a corresponding enzyme, with the energy supplied from the oxidation of carotenoids [18]. The glutamate synthase cycle, which involves two processes acting in succession and catalyzed by the enzymes glutamine synthetase and glutamate synthase, assimilates the NH₄ that arises from both NO₃ assimilation and the NH₄ received directly by the roots [19]. The cyclic method in which the amino acid glutamate acts as both an acceptor and a product of ammonia absorption is a distinguishing feature of this route [20]. In this cycle,

NH_4 is integrated into glutamine by glutamine synthetase, which uses ATP energy to link NH_3 to the carboxy group of glutamate [9]. These reactions take place in chloroplasts in leaf cells and most likely in plastids in roots [21]. The light-trapping system in chloroplasts provides the energy to replenish ATP, whilst other enzyme systems in root cells oxidize carbohydrates to produce energy for ATP regeneration [16]. Another glutamine synthetase isoform, which is not similar to the plastid enzyme, is found in the cytoplasm of both leaf and root cells [22]. Any free NH_3 or NH_4 can be assimilated by the cytoplasmic enzyme, independent of its source (from either deamination of amino acids or absorption from the soil). The glutamine synthetase reaction is a detoxifying process that prevents harm from NH_4 or NH_3 accumulation in addition to creating the critical intermediate, glutamine [12]. The amino group (MNH_2) transfers to oxoglutarate by glutamate synthase to generate two molecules of glutamate after the production of glutamine [11]. This reaction can happen in shoots or roots, and the enzyme is found in plastids in both cases [17]. Plant cells have three glutamate synthase isoforms, each of which uses a distinct electron donor [14]. Reduced ferredoxin, which is produced directly from the trapping of light energy, serves as an electron donor in leaf chloroplasts. In root cells, on the other hand, the electron donor is NADH or NADPH, with the energy to reduce the oxidized form of the pyridine-linked nucleotides derived from carbohydrate oxidation [18]. The amino group from glutamate is transferred to the 2-oxy group (BO) of a 2-oxoacid through a series of related reactions mediated by specific transaminases [4]. The 20 amino acids essential for protein synthesis are created through biochemical modification of glutamate, glutamine, and the array of amino acids produced by transaminase processes [17]. These amino acids can also be converted into a range of complex nitrogenous chemicals involved in plant growth and metabolism (e.g., chlorophyll, growth regulators, alkaloids, nucleic acids) [5].

2.2. Importance of Nitrogen

Crop growth and productivity are the combined effects of a large number of components and metabolic processes that operate at varying intensities throughout the crop's life cycle. The interdependence of N and C metabolism complicates describing an independent role for N in maximizing crop productivity. Nonetheless, four major roles for N have been proposed for increasing rice and maize yields, and these roles appear to be applicable to a wide range of crops:

- 1) Creation of photosynthetic capacity
- 2) Preservation of photosynthetic capacity
- 3) Determination of sink capacity (The number and potential size of seeds)
- 4) Upkeep of functional sinks throughout the year.

The goal of developing photosynthetic capacity is to ensure that the availability of N does not limit the development of the photosynthetic apparatus (enzymes, pigments, and other compounds needed for photosynthesis). Within limits and in the absence of other limiting factors, an increase in N supply

promotes growth, the composition of N and chlorophyll, and the photosynthetic capacity of leaves. Nitrogen supply has also been shown to influence the synthesis of photosynthetic carboxylating enzymes by influencing transcription and/or messenger RNA stability [23]. Collectively, these effects result in greater light interception, higher canopy photosynthesis, and higher yield [12]. However, because little N is accumulated by the leaf after it has reached full expansion [24], a sufficient supply of N must be available throughout the development of each leaf if the individual leaves are to attain their full genetic potential for photosynthetic capacity [17]. Plants must not only establish photosynthetic capacity, but also maintain it throughout the grain-filling period, in order to achieve high yields. As a result, once established, enough N must be available to sustain the photosynthetic apparatus. This role is especially important because cereal grain dry matter accumulation is dependent on current photosynthesis [18]. While aboveground plant parts can absorb gaseous NH_3 via stomata, the amounts absorbed are limited in clean air.

2.3. Nitrogen Uptake

NO_3 uptake is a dynamic process that must overcome an unfavorable electrochemical gradient between the soil and the root. However, due to the gradient, NO_3 can efflux or leak back out of the root. Efflux has been described as a passive diffusion or a carrier-mediated process [3] but in either case dependent on the internal concentration of NO_3 in the root. As a result, the net accumulation of NO_3 is a function of the difference between influx and efflux. As might be expected, efflux is greatest when high concentrations of NO_3 have been accumulated by root tissues [25]. Unlike NO_3 uptake, NH_4 absorption does not have a long lag under N-depleted settings [26], albeit it can be divided into two phases. Because the early phase of NH_4 is unaffected by low temperatures or metabolic inhibitors, it is assumed to occur naturally [25]. The second step of NH_4 absorption, on the other hand, requires metabolic energy and is susceptible to low temperatures and inhibitors [24]. The active phase of NH_4 uptake in some plant species is likewise multiphasic, with uptake and growth rates connected with deficit, luxury consumption, and toxicity [27].

2.4. Physiological Roles for Nitrogen in Crop Productivity

The majority of nitrogen in the leaf is connected with proteins in the chloroplast (60 percent in C_4 plants and up to 75 percent in C_3 plants) and these proteins are subject to breakdown and remobilization of the resulting amino acids [5]. When a result, as leaves age and senesce, their photosynthetic capability falls, resulting in a decrease in assimilate supply and yield. Many studies have found a loss of photosynthetic activity and organic nitrogen from leaves at the same time, particularly during seed formation [6]. The losses in leaf N and photosynthesis initiated at or near pollination and declined nearly linearly during the grain-filling period.

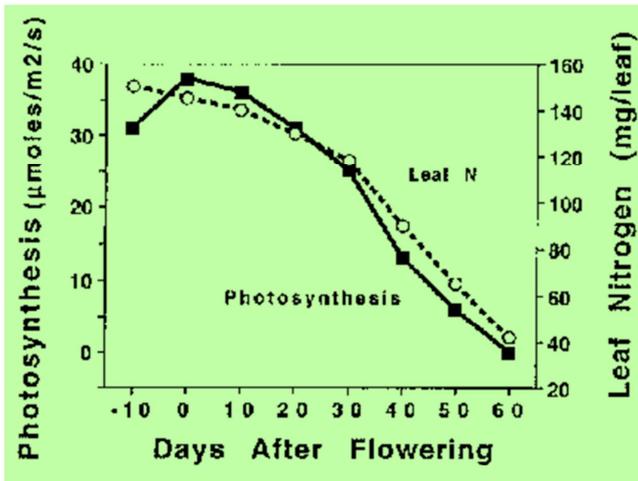


Figure 1. Shows relations between photosynthesis and leaf area from days after flowering; Source; Handbook of Plant and Crop Physiology (Marcel Dekker, Inc. 2001).

Although it is obvious that N loss from the leaf reduces photosynthetic activity, management measures that improve N supply (such as extra side dressings or foliar N sprays) do not always result in increased leaf N status and photosynthetic activity [24]. The absence of these effects is most likely due to the chloroplast's encoded and produced photosynthetic enzymes (the major subunit of RuBPCase) [8]. Regardless of N availability, the chloroplast loses much of its ability to produce these proteins after full leaf growth [27]. This occurrence suggests that supplementing N to maintain photosynthetic activity may be of limited utility until a method for reactivating protein synthesis in the chloroplast is discovered.

The formation of reproductive sink capacity is another crucial role for N in ensuring high crop plant yield. The number and possible size of grains determine the sink capacity of a cereal plant. The number of grains per unit area is determined by the number of ears per unit area, the number of florets per ear, and the proportion of florets that develop into grain [6], and the size of individual grains is determined by the number of endosperm cells and starch granules [28].

In either case, reproductive initials, like all growing tissues, are characterized by high concentrations of N and high metabolic activities [23]. This need could indicate that adequate levels of both C and N assimilates are required for complete expression of the genetic capacity for grain initiation and early growth. Grain number is usually more closely connected to yield than other yield components in cereal crops [12]. As a result, numerous studies have discovered that higher N yields are due to more grains per plant. This improvement in wheat was linked to increased tiller production and survival, as well as a decrease in floret abortion [6]. However, researchers rein the case of maize, N availability primarily influences kernel number by reducing kernel abortion [27]. In, an example of the effect of N supply on maize kernel number and abortion is shown. The number of kernels increases as the N supply increases from insufficient to sufficient, resulting in a decrease in kernel

abortion [29]. They studies that, N supply can also affect individual grain weights, perhaps by means of a change in endosperm cell number.

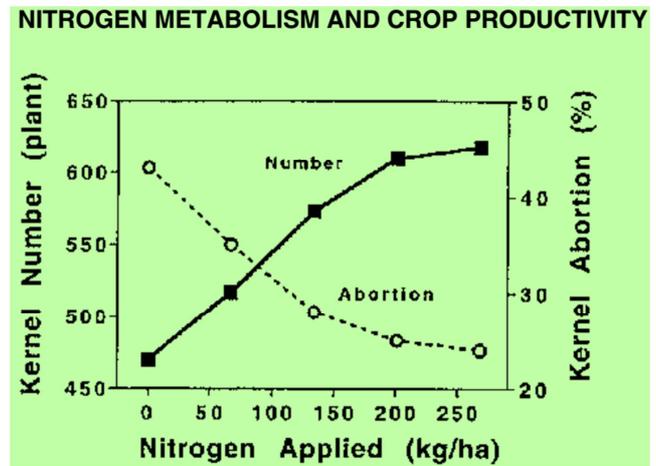


Figure 2. The effect of N fertilizer rate on kernel number and kernel abortion of maize. Values are averaged over two hybrids. Source; Handbook of Plant and Crop Physiology (Marcel Dekker, Inc. 2001).

Although changes in kernel weight might affect yield, the quantity of ears and grains is usually the yield component most affected by N supply [29]. Because vegetative development in cereal crops is minimal after flowering, the N subsequently acquired, or remobilized from the vegetation, is used completely for grain development, according to those researchers. The fact that properly fertilized cereal crops typically contain 9 to 13 percent protein in the grain demonstrates the necessity for nitrogen [28]. During the grain-filling period, variations in photosynthesis and N content of a selected maize leaf (the first leaf above the ear) were observed [30]. They also claimed that N availability inside the plant and to the grain is linked to kernel growth, and that the amount of storage protein deposited is only an accurate picture of N supplies.

Moreover, argued that, needs for N by developing kernels could include embryo growth and the initial and continued synthesis of enzymes needed for energy generation and the deposition of storage products in the kernel [10]. Embryo development could affect the kernel's hormonal balance because a large portion of kernel phytohormones produced by the embryo [29]. Because several of the key classes of phytohormones either contain N (auxins, cytokinins, polyamines) or are synthesized from amino acids (auxins, ethylene, polyamines), an adequate supply of N may be needed for their production [16]. In terms of storage product creation, N supplementation of developing maize kernels has been demonstrated to improve their ability to manufacture proteins and use carbohydrates for starch biosynthesis [7]. They also stated that nitrogen fertilization has a significant impact on endosperm enzymology and the deposition of storage proteins in the endosperm, and that it appears that at least a portion of the yield increase resulting from N fertilization is due to a change in kernel metabolism in response to N fertilization [29].

2.5. Interactions of Carbon and Nitrogen

The ability of a plant to collect metabolizes, and use C and N assimilates, as well as its genetic potential for optimal grain production, determines grain output. The relative availability of C vs N in cereal crops (about 44 percent C vs. 1.5 percent N) requires that photosynthesis plays a dominant role in reaching maximum yields. The generation of C assimilates and their usages for reproductive development are both influenced by N metabolism [31].

C and N interact at numerous levels in plant metabolism, as evidenced by the use of reduced ferredoxin in NO₂ reduction and NH₄ assimilation [32]. When attempting to characterize an autonomous role for either C or N in achieving optimal productivity, this interdependence in C and N metabolism causes issues. The complexities involved in understanding how C and N interact to effect production are exemplified by grain composition. In cereals, a negative association between grain yield and protein percentage has been seen, particularly in cultivars chosen for excessively high or low grain protein percentages [33]. This link has been explained by the increased metabolic cost associated with protein synthesis compared to carbohydrate synthesis [11]. This hypothesis appears improbable, given evidence that carbohydrate availability does not generally limit kernel development and progress toward identifying and breeding high-protein, high-yielding cereals [26]. The proportional supply of C and N from the vegetative plant may have a role in the negative relationship between grain number and grain weight [1].

The amount of starch and protein accumulated in maize grain appears to be controlled by the content of assimilates (C and N) directed to the kernel by the mother plant [6]. However, it has been shown in other studies that the genotype of the kernel determines the range of grain composition, with external factors modulating the phenotype within this range to a large or small degree [9]. Alternatively, zygotic factors and the source supply could work together to influence grain composition phenomena also complicate our understanding of how C and N relationships control grain composition because plants can make up for a lack of current assimilate (both C and N) with enhanced remobilization from the vegetation [3, 5, 10, 32]. On a whole-plant basis, the supply of N often appears more limiting for grain development than does the supply of carbohydrate. In the case of maize, the plant's ability to deliver N to the ear was more limiting than its ability to produce photosynthate, because net remobilization of vegetative N happened sooner and was far more widespread than the remobilization of vegetative carbohydrate [10, 11]. Although shading plants during grain fill decreased yield and enhanced the remobilization of both dry matter and N, the availability of newly reduced N was still more limiting to grain fill than current photosynthate [9, 16]. Similarly, although supplemental illumination to the lower two-thirds of the canopy increased carbohydrate status and yield, these effects could not separate from an enhancement in the total

accumulation, and the tissue concentration, of N [2]. Collectively, these data suggest that the availability of N to and within the plant is more variable than the availability of photosynthate and at least as limiting to grain development.

There is a conspicuous lack of recorded results of experiments to determine the effect of variations in the nutrient supply of plants on their photosynthetic and respiratory rates, working with excised leaves of *Helianthus*, found that if the petioles were immersed in nutrient solutions containing certain amino acids the respiratory rate was increased [12, 18]. They also studied the photosynthetic rates of excised leaves after varying periods of exposure to darkness, and found some correlation between the respiratory rates and the photosynthetic rate. Researcher grew barley plants with various deficiencies of nutrient supply along with others with complete nutrient solution [33]. They studied using excised leaves, also the effect of mineral deficiencies on the assimilation rate [16]. The purpose of the work here described was to determine the rates of photosynthesis and respiration of leaves attached to the plant, and of whole plants grown under different conditions of nitrogen nutrition, when such plants subjected to various changes in the relative planes of nutrient supply [28].

For example, if plants had grown for a period with very low nitrate supply, so that they became relatively high in reserve carbohydrates, their photosynthetic and respiratory rates studied first under the low plane of nitrate supply, then they were shifted to a high plane of supply and these same rates continuously determined. Similarly, tests were made of plants on a high plane of nitrate supply and then shifted to a low one, with various intermediate conditions, as seemed desirable at any given time.

F. Gastal and G. Lemaire [33] Conduct their experiment on monocotyledonous perennial *Carex Aquatilis* and found the following result; Shoots were grown in open (28 shoots m⁻²) and dense stands (280 shoots m⁻²). For fully-grown stands, the distribution of relative photosynthetic photon flux density (PPFD) and leaf nitrogen per unit leaf area over canopy depth was determined [3]. Light response of photosynthesis measured on leaf segments sampled at various heights in the stands. Relations between parameters of these curves and leaf nitrogen investigated [34]. Simulations showed that in the open stand daily canopy photosynthesis not affected by nitrogen redistribution in the canopy [15]. For the dense stand however, a uniform nitrogen distribution would lead to only 73% of the maximum net carbon gain by the stand under optimal nitrogen distribution [5]. The actual canopy photosynthesis was only 7% less than this theoretical maximum; the actual nitrogen distribution of the dense stand clearly tended to the optimal distribution [8]. The vertical pattern of the nitrogen distribution largely determined by the minimum leaf nitrogen content [13]. The relatively high minimum leaf nitrogen content found for *Carex* leaves may perhaps be necessary to maintain the physiological function of the basal parts of the leaves.

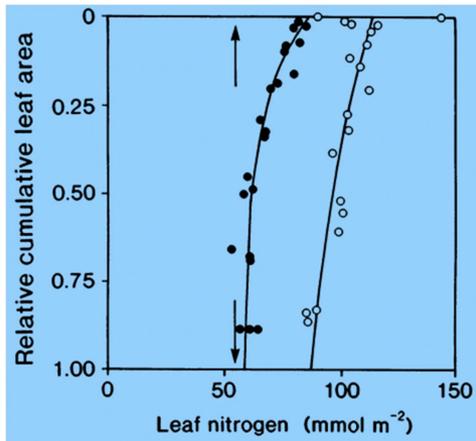


Figure 3. Leaf nitrogen per unit leaf area (n_l) as the function of relative cumulative leaf area. Open circle refers to open stand, closed circles refers to dense stand. Source; *Handbook of Plant and Crop Physiology* (Marcel Dekker, Inc. 2001).

Source; The vertical distribution of nitrogen and photosynthetic activity at different plant densities in *Carex acutiformis* (Kaufman 1949).

C. H. Foyer, S. Ferrario-méry, and G. Noctor [31] studied the effects of nitrogen availability on sunflower (*Helianthus annuus* L., var. *catissol*) growth and photosynthesis in a greenhouse under natural photoperiod. Furthermore, researchers discovered that greater nitrogen concentrations resulted in higher shoot dry matter production per plant, with the effect visible as early as 29 days after sowing (DAS) [33]. The influence of nitrogen on leaf output and individual leaf dry matter is mostly responsible for the differential in dry matter production [35]. The nitrogen supply has little effect on the specific leaf weight (SLW). High nitrogen diet significantly increased the target leaves' photosynthetic CO₂ assimilation. Regardless of nitrogen, though. The sunflower plants were grown in vermiculite under two nitrogen supply conditions, with nitrogen supplied as ammonium nitrate in one and nitrogen supplied as ammonium nitrate in the other. Before the conclusion of leaf growth, photosynthetic CO₂ uptake began to drop. Despite the fact that nitrogen had no effect on stomatal conductance (g_s), high-N grown plants exhibited lower intercellular CO₂ concentration (C_i) than low-N grown plants. To only at the start of leaf growth did the rate of transpiration rise in high-N growing plants. This did not, however, result in reduced intrinsic water use efficiency (WUE).

Another scholars [33] found that, Nitrogen-deficient plants had significant lower leaf nitrogen and chlorophyll a contents. They also found a significant reduction in photosynthetic capacity. A tolerance difference between cultivars was observed: 'Meski' proved to be more efficient in maintaining CO₂ assimilation rates than 'Koroneiki' under nitrogen deficiency, which was reflected by increased photosynthetic nitrogen use efficiency [35]. Accumulation of carbohydrates, especially starch, mannitol, sucrose and glucose, was observed in nitrogen-deficient leaves [36]. This indicates that both the high carbohydrate and the low nitrogen content inhibit photosynthesis in nitrogen-deprived

olive plants [25]. Total biomass was strongly reduced (mainly caused by a decrease in leaf dry weight) under nitrogen deficiency for both cultivars, but root: shoot ratio was hardly affected [29]. Elongation of fine roots was enhanced in 'Koroneiki' under severe nitrogendeprivation. In general effects of nitrogen deficiency on CO₂ assimilation, carbohydrate content and biomass have been observed on the two cultivars.

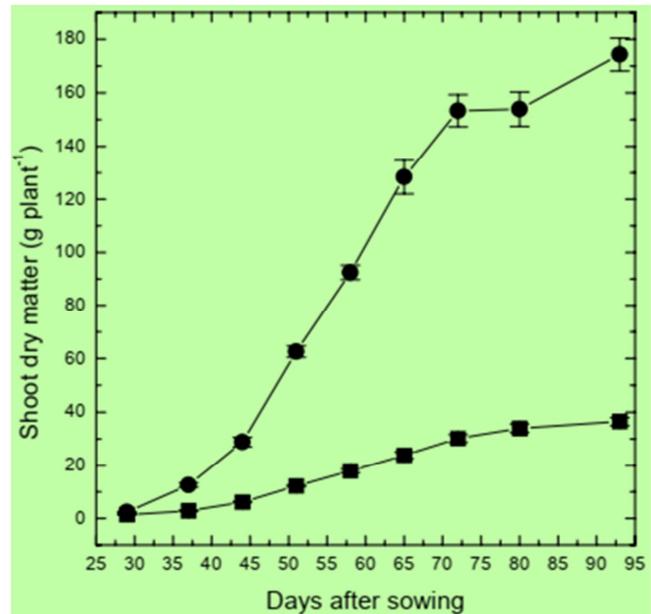


Figure 4. Relation showing DM and accumulation of N rate.

Source; Effect of nitrogen supply on growth and photosynthesis of sunflower plants grown in the greenhouse (Von Kienlin et al. 2004).

G. Hofman [27] found on two species of diatoms nitrogen and total protein per cell decreased with increasing growth light in both species when grown under the lower-nitrogen media. Cells growing under lower-nitrogen media increased their cellular allocation to RUBISCO and their rate of electron transport away from PSII, for the smaller diatom under low growth light and for the larger diatom across the range of growth lights [31].

The smaller coastal diatom *Thalassiosira pseudonana* is able to exploit high nitrogen in growth media by up-regulating growth rate, but the same high-nitrogen growth media inhibits growth of the larger diatom species [25]. The conducted their experiment on two species of marine phytoplankton groups diatoms which span the widest range of cell size, with resulting effects upon their nitrogen uptake, photosynthesis and growth responses to light. Two strains of marine centric diatoms differing by 4 orders of magnitude in cell bio-volume in high (enriched artificial seawater with 500 $\mu\text{mol L}^{-1}$ NO_3^-) and lower-nitrogen (enriched artificial seawater with 10 $\mu\text{mol L}^{-1}$ NO_3^-) media, across a range of growth light levels were grown.

A. Adelsi et al. [17] conducted their experiment on *Solanum lycopersicum* (tomato) to investigated photosynthetic pigment accumulation and yield as to

ascertain the maximum concentration of nitrogen needed for optimum production. They tagged Seeds of *S. lycopersicum* with VG-TH-017 which were firstly raised in nursery bed. At the end of 28th day after sowing, the seedlings with uniform height were transplanted into experimental pots with 4 seedlings per pot under greenhouse [17]. All the experimental pots were 40 in total, 4 levels of nitrogen (KNO_3 and NH_4NO_3) treatment (n, N, 5N, 10N) with 10 replicates. All the plants in the four treatments received 200ml of distilled water at 6a.m. in the morning every day. At 6p.m. in the evening, 100 ml of the differential treatments were applied [30]. They determined photosynthetic pigments spectrophotometrically. The number of flowers and fruits per plant per pot were counted and recorded. The fruit lengths and fruit diameters in each treatment were determined with the use of a Vernier Caliper. The fruits biomasses were also determined. They found that 10N-plants and 5N-plants had leaves with deep-green coloration indicating an increase in chlorophyll content as well as an increase in the photosynthetic capacity. The highest number of flowers and early flowering discovered in 10N-plants and 5N-plants. The best yield was obtained in the treatments for the 5N-plants in which the concentration of nitrogen in the nutrient solution had been increased to a factor of 5. It is therefore suggested that when the seeds of tomato plants VG-TH-017 are to be grown, the 5N treatment is the most suitable level of application.

Conducted their under two nitrogen (N) supplies with rice plants, and the steady-state and dynamic photosynthesis rates were measured under 28 and 40°C. And they found that High temperature significantly increased leaf hydraulic conductance (K_{leaf}) under high N supply (HN) but not under low N supply (LN) [3, 15]. The increased K_{leaf} maintained a constant leaf water potential (ψ_{leaf}) and steady-state stomatal conductance (g_s), sat under HN, while the nine leaf and (g_s), sat significantly decreased under high temperature in LN conditions. This resulted in a more severe decrease in steady-state photosynthesis (A_{sat}) under high temperature in the LN conditions. After shifting from low to high, high temperature significantly delayed the recovery of photosynthesis, which resulted in more carbon loss under flecked irradiance. These effects obtained under HN to a lesser extent than under LN supply. Therefore, they concluded that nitrogen could alleviate the inhibition of photosynthesis caused by high temperature stress under both steady state and flecked irradiance. High temperature stress significantly inhibits photosynthesis under both steady state and flecked irradiance.

G. Huang et al. [3, 15] tried to investigate effects of nitrogen on photosynthetic characteristics of leaves from two different stay-green corn (*Zea mays* L.) varieties at the grain-filling stage were studied. Using a stay-green inbred line (Q319) and a non-stay-green inbred line (HZ4) as materials, using fast chlorophyll fluorescence-induction kinetics and 820 nm light-absorption curves, they analyzed the influences of nitrogen supplementation on photosystem I (PS I) and photosystem II (PS II) [19]. They showed that nitrogen

fertilization has significant effects on promoting the net photosynthetic rate (Pn) in leaves at the grain-filling stage and on single-plant grain yield at the harvest stage (PB0.05) in Q319, whereas there is no significant effect in HZ4. Analyses performed using JIP-Test showed that nitrogen fertilization significantly increased electron donor and acceptor performance in the reaction center of PS II (PB0.05). The increased performance of the electron transport chain at a point after the electron acceptor in the PS II reaction center was greater in Q319 than in HZ4, reducing excessive excitation energy production in PS II and significantly improving the coordination between PS II and PS I. Although the performance of the electron transport chain after the electron acceptor in the PS II reaction center was increased in HZ4, the increase was not substantial enough to improve the coordination between PS II and PS I; therefore, Pn and grain yield were still significantly lower than those of Q319.

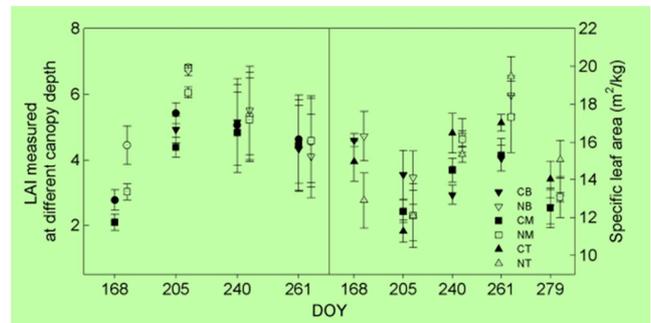


Figure 5. Shows relation between N content of leaf in different Canopy layer. Source: Impact of nitrogen allocation on growth and photosynthesis of *Miscanthus* (*Miscanthus 3 giganteus*) (D. Wang et al. 2012).

Nitrogen (N) addition typically increases overall plant growth, but the nature of this response depends upon patterns of plant nitrogen allocation that vary throughout the growing season and depend upon canopy position. [1] investigated across a canopy profile in *Miscanthus* (*Miscanthus giganteus*) under two N treatments (0 and 224 kg ha⁻¹) to determine whether the growth response of *Miscanthus* to N fertilization related to the response of photosynthetic capacity and nitrogen allocation. In addition, they found that *Miscanthus* yielded 24.1 Mg ha⁻¹ in fertilized plots, a 40% increase compared to control plots. Photosynthetic properties, such as net photosynthesis (A), maximum rate of rubisco-carboxylation (V_{cmax}), stomatal conductance (g_s) and PSII efficiency (F_v'/F_m'), all decreased significantly from the top of the canopy to the bottom, but were not affected by N fertilization. N fertilization increased specific leaf area (SLA) and leaf area index (LAI) [2]. Leaf N concentration in different canopy layers increased by N fertilization and the distribution of N concentration within canopy followed irradiance gradients. These results show that the positive effect of N fertilization on the yield of *Miscanthus* was unrelated to changes in photosynthetic rates but achieved mainly by increased canopy leaf area. Vertical measurements through the canopy demonstrated that

Miscanthus adapted to the light environment by adjusting leaf morphological and biochemical properties independent of nitrogen treatments. GPP estimated using big leaf and multilayer models varied considerably, suggesting a multilayer model in which V_{cmax} changes both through time and canopy layer could be adopted into agricultural models to more accurately predict biomass production in biomass crop ecosystems.

3. Conclusion

Because of the high dependence of crop plants for nitrogen and its numerous important roles in growth and development, N is the mineral nutrient element that most often limits crop productivity. N mineralization from the soil is normally too low to support desired production levels, soil N levels typically increased through fertilization. However, the complex cycle of N in the environment causes uncertainty in N fertilizer management, increasing the chances for economic loss and environmental damage. Nitrogen use and productivity of crop plants is also complex, resulting from an interaction of biochemical, physiological, and morphological processes in the plant. Through one could understand N is the important nutrients that react with many nutrients chemical compound in the cell of plant and make life exist.

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