THE EFFECT OF PLANT ORIENTATION AND THE EFFICIENCY OF UTILIZATION LIGHT ENERGY ON GROWTH AND YIELD OF ZEA MAYS

By

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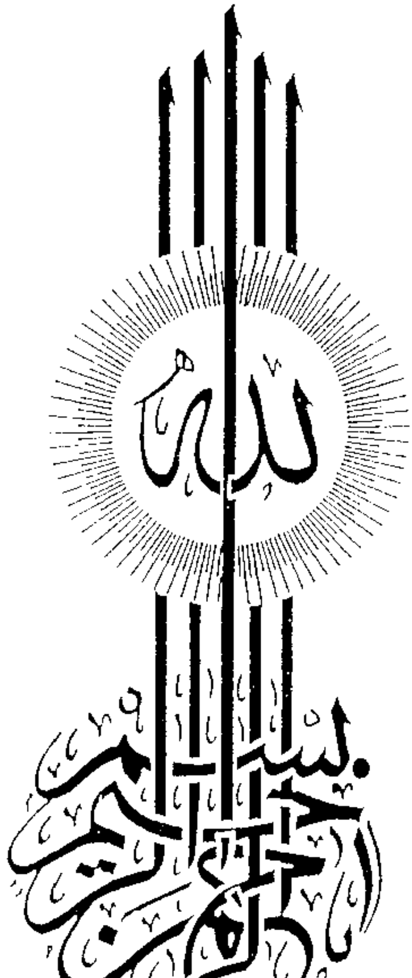
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CONTENTS

INTRODUCTION

The orientation of plant leaves in the field exerts a marked effect on the amount of light energy intercepted by the leaves. Consequently, a considerable increase in absorption of light energy within the crop canopy can be achieved through the proper position of spatial distribution of leaves in maize field.

The amount of light energy intercepted by crop foliage is influenced by many factors among which plant population, growth of foliage and spatial distribution of leaves are the most important.

The angle of incidence (θ) of incoming radiation is greatly influenced by leaf orientation.

This work was performed to investigate the effect of orientation of maize leaves on the growth, photosynthetic apparatus and photosynthetic activity of maize plants.

REVIEW OF LITERATURE

So far the author is aware, the relationship between leaf orientation and the growth and yield of maize plants is quite scarce. Consequently, the absorption of light energy within crop canopy, and the effect of light on growth of maize crop is included.

Aubertin and Peters (2) registered some observations of maize planted at 31,000 and 15,000 plants/ac in rows 20-in. and 40 in. apart. The net radiation over the crop was found to be higher in 40-in. rows at both level of population. One noticeable field effect of these findings (The capacity of the closely planted crop to absorb energy) was the greater suceptibility to wilting at high population of the 20-in. as compared with 40-in. rows crops. Moreover they found that plant population and row widths affected the relative amounts of energy absorbed by the plants and by the soil. A considerable increase in absorption of light energy within the crop canopy can be achieved through the process of spatial distribution of plant in maize field.

Denmead et al. (12) measured the net incident radiation at one meter above the crop, and at 115 cm above the ground level within the crop canopy in a high-yielding maize stand (containing 15,700 plants/ac.in rows 40-in. apart). After the development of maximum leaf area, the crop canopy retained 75% of net incident radiation. Also they have estimated that a row spacing of 24-in. would have retention of 85 - 90% of net radiation. They reported that on a clear days, after maximum leaf area development, the net radiation at the ground constituted only 25% of the total net radiation measured above the crop, while 75% being expended within the crop canopy. It was estimated that closer row spacing than 40 inches could increase the energy available to the crop for photosynthesis by 15 to 20%.

Pendeleton and Seif (64) noticed that the competitive effect between normal and dwarf maize plants were associated primarily with light. It was found that a single row of dwarf plants borded by normal plants yielded 30% less grain than when borded by dwarf plants. However a single row of normal plants, borded by dwarf plants, yielded only 6% more than when bordered by normal plants.

Ustenko and Priezzhev (83) showed that absorption of photosynthetically active radiation and total radiation increased with increasing leaf area up to a maximum of 42,500 m^2/ha.

Krideman et al. (48) studied photosynthesis and its relation to leaf orientation, and light interception and its response to an increasing angle of incidence (θ) of incoming radiation. They found that the intensity of light falling upon a leaf can be reduced from geometrical optics to be proportional to cos θ and their reported data suggested that the photosynthetic activity of leaves exposed to limiting light intensity follows a similar relationship.

Effect of light intensity on photosynthetic apparatus:

Bjorkman and Halmyren (3) demonstrated that the compensation point and light saturation of the leaves of sun plants were higher at light than that in those of shade plants. Therefore, growing the plants under different light intensities(artificial or natural) also induced changes in the photosynthetic apparatus. The leaves of plants grown under high light intensity showed photosynthetic light curves much similar to those of sun plants. Meanwhile, the photosynthetic light curves of shaded plants were similar to those of shade plants.

The chlorophyll content in the leaves of solidage virgaurea plants tended to increase with increasing light intensity, yet chlorophyll a were more sensitive than chlorophyll b.

Kokhnovitch (42) reported that chlorophyll content in the leaves of cucumber and radish plants increased with increasing light intensity up to 20.10^3 erg/cm^2-sec., after which further increase in light intensity did not induce more chlorophyll accumulation. On the other hand, a decrease in pigment content was reported in other plant species. Generally, there was no clear correlation between the accumulation of chlorophyll and carotenoids under different light intensities. The amount of chlorophyll a + b in the leaves of Onion plants increased with increasing light intensity up to 20×10^3 - $25x10^3$ erg/cm^2-sec.

The rate of photosynthesis base a linear relation to the light intensity (35,80).

Teffers and Shibles (81), found an interaction between leaf area index (LAI) and solar radiation in their effect of photosynthesis, whereas Pearce _et al._ (62) noticed that specific leaf weight (SLW) and net photosynthesis (pn) were positively correlated (r = 0.790). Net photosynthesis increased from 20 ± 7 to 50 ± 8 mg Co_2 dm^{-2} hr^{-1} when SLW increased from 1.9 to 5.3 mg cm^{-2}. Heichel and Musgrave (30) reported that photosynthetic rates were correlated with fresh weight of leaf lamina and days between emergence and silking, but not with dry weight of leaf lamina, or with water content or soluble solids of leaf.

Zhebin (90) found that the intensity of photosynthesis ranged from 7.7 to 13.4 mg Co_2/100 cm^2/h. for convertional cultivars and from 9.7 to 14.6 mg Co_2 for hybrid C.V. In another trails in which photosynthetic intensity ranged from 12.8 to 19.2 mg Co_2/h., increasing the fertilizer rates increased the intensity of photosynthesis.

Effect of light intensity on growth:

Mc Calla (51), Stinson and Moss (78), Early et al. (15), Pedlenton et al. (65) and El-Mankabaty (18), reported dwarfing effect for high light intensity on maize plants. However, Mc Calla et al. (51) showed that shade treatments altered the quality of incident light. This in turn might alter the hormonal balance which could alter plant height.

Hesketh and Musgrave (34), Moss et al. (58), Thomas and Hill (82) and Verduin and Loomis (86) found a high correlation between rate of photosynthesis in crop plants with light intensity from a low intensity to light saturation of the leaves. Verduin and Loomis (86) found that light saturation of maize leaves to be about 2,500 F.C. More recently Hesketh and Musgrave (34) demonstrated that the net assimilation rate of a single maize leaf continued to increase with increasing light intensity up to 10,000 F.C., the normal maximum on a clear day at Ithace, New-York. Schimizu *et al.* (72) and Knipmeyer *et al.* (43) came to the same conclusion. Knipmeyer *et al.* (43) and some other investigators found that there was an inverse relationship between the dry matter content of plants and shading density.

Galal and Farrag (22) in Egypt showed that the different distributions of plants had clear effect on illumination intercepting between maize plants.

El-Sayed (20) in Egypt found that the percentage of light intensity between maize plants to that of full light intensity in the field increased as plant population decreased. He reported that the illumination between plants differ according to age of plants, i.e. the percentage of light intensity between plants decreased with increasing plant age up to about silking time then increased with age. These results were true in both summer and Nili seasons. He added also that the leaf area per plant increased with age from the age of 35 days up to the period between tasseling and silking where it reached its maximum and after that it declined.

Prine et al. (68) in Florida, measured the light intensity within four populations of Dixie 18 corn grown in 38-inch rows. They found that the amount of the intercepted light reached the bottom leaves and the soil decreased as stand density increased from 5,000 to 17,000 plants per acre. At high stand density, only a few scattered spots of unintercepted light reached the soil surface.

Watson (87) found that the value of leaf area index (L.A.I.) increased with increasing plant population in the contrary of leaf area per plant.

Shibles and Weber (76) showed that percentage of solar radiation interception increased with increasing leaf area development of Soybean, while Pendlenton, et al. (65) showed slightly larger leaf area of maize plants in the border rows receiving reflected light than control plants in their experiments.

Hageman, et al. (25) and Knipmeyer, et al. (43) found that the dry weight of maize plants decreased as light intensity reduced. Hoyt and Bradfield (37) suggested that, low amount of dry matter produced in the bottom leaves of maize was due to the reduction in light intensity between the foliage because of that shading occurred by the above leaves.

Shibles and Weber (76) found that the amount of solar radiation intercepted by canopy of soybean and dry matter production increased with increasing leaf area development. Duncan, et al. (14) showed that the shading effect in maize field was small at low plant population but increased with increasing plant density.

Grossman (11), reported that with increasing maize crop density plant height and stem diameter decreased while leaf area index increased.

Buttery, et al. (8) noticed that mean relative growth rate mean net assimilation rate (NAR) increased with increasing plant density, while mean crops growth rate (C.G.R.) and leaf area ratio (L.A.R.) decrease in four maize experiments out of six experiments. The least fitting regression of NAR on LAI was a straight line, in the other experiments the relationship was curcilinear.

Effect of light intensity on yield:

Several investigators, reported that shading reduced the grain yield of maize (15, 18, 25, 34, 43, 44, 53, 57, 58, 64, 78, 82). In addition Prine (67), Bokde (6), Pendelenton, et al. (65) on maize and Johnston, et al. (41) on Soybean reported that yield increased with increasing light intensity.

Pendelenton, *et al*. (65) found that under field conditions all leaves on maize plants are not light saturated, even at low rates of planting, and therefore, light appears to be the primary ecological factor limiting the grain yield of this crop when grown under highly productive conditions.

Crossman (11),found that as crop density increased, individual plant yield of maize decreased owing to a fall in total assimilatory leaf area and deformation of reproductive organs.

Schmidt and Colville (73), found that grain yield per hectar were significantly reduced when 75 to 100% of solar energy available to leaves located below the ear was intercepted by black polyethylene. They added that restricting light penetration to these leaves by 25 to 50 % had little effect on grain yield per hectar. They showed also that leaf or stem removal reduced grain yield by 22 to 44 %. Leaves located either below or above the ear leaf were equally efficient in the production of grain per unit leaf area basis. Artificially shade leaf tissues continued contributing to grain yield although with greatly reduced efficiency per unit leaf area. Removal of all tissues above the ear reduced ear weight 45%, also weight per 100 Kernels was reduced as a result of leaf removal.