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THE EFFECT OF LIGHT QUALITY ON MAIZE: A TOOL FOR WEED PLANTS MANAGEMENT

Efecto de la calidad de la luz en el cultivo del maíz: una herramienta para el manejo de plantas arvenses

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ABSTRACT. Light signals such as the red to far-red ratio (R/FR) reflected from stem and leaf surfaces of neighboring weeds can trigger a shade avoidance response in maize seedlings, resulting in morphological changes. Two different experiments were conducted under conditions of non-limiting resources with the objective to determine the effect of neighboring weeds competition for light in corn plants in early stages of development. In the first experiment; we used Turface® as soil for planting corn seeds, it consisted in two treatments (weedy –free and weedy). Perennial ryegrass (*Lolium perenne* L) was using as a model weed species, in all parameters studied, a decrease was observed in the experiment with weed after 48 h of planting except stem length 48 h before this was greater in the weed-free treatments opposite effect occurring after 48h. The second experiment consisted in three treatments with different densities(low, medium and high) with nine, 28 and 81 plant respectively, the effect occurred in the different parameters behaved low density higher, except in the stem large , which was greater in the high density. Where the corn plants had an avoidance reaction by weeds shade, due to light competition, because was the unique limitant factor, inclusively when the plants were high on V4 stage. This change in growth may help explain the importance of early-season weed control in corn.

Key words: *Zea mays,* radiation, interespecific competition, *Lolium perenne*

RESUMEN. Las señales de luz como el rojo y el rojo lejano (R/RL) son reflejadas desde el tallo y la superficie de las hojas de las arvenses vecinas, estas pueden desencadenar una respuesta por efecto de sombra en las plántulas de maíz, lo que resulta en cambios morfológicos. Dos experimentos de laboratorio se llevaron a cabo bajo condiciones controladas con el objetivo de determinar el efecto de las arvenses vecinas y la competencia por luz sobre plantas de maíz en etapas tempranas de su desarrollo. En el primer experimento, se utilizó Turface® como suelo para plantar las semillas de maíz, y se estudiaron dos tratamientos (libre de arvenses y con arvenses). Raigrás (*Lolium perenne* L) se utilizó como especie de arvense. En todos los parámetros estudiados se observó una disminución en el experimento con arvenses después de las 48 h de la siembra excepto en la longitud del tallo, que antes de las 48 h fue mayor en el tratamientos libre de arvenses, ocurriendo el efecto contrario después de las 48 h. El segundo experimento, constó de tres tratamientos con diferentes densidades de siembra (baja, media y alta) con nueve, 28 y 81 plantas respectivamente. Los diferentes parámetros se comportaron de forma mayor en la densidad baja, excepto el largo del tallo, que fue mayor en la densidad alta, donde las plantas de maíz tuvieron una reacción de evitación por sombra de las arvenses, debido a la competencia por luz, ya que era el único factor limitante, incluso cuando las plantas eran mayores a la etapa V4. Este enfoque puede proporcionar una oportunidad para mejorar la competitividad del cultivo en condiciones de alta densidad.

Palabras clave: *Zea mays*, radiación, competencia interespecífica, *Lolium perenne*

INTRODUCTION

Weed interference is one of the most important factors in reducing crop yields worldwide (1). Interespecific competition between crops and weeds occurs mainly for light, water, nutrients and physical space (2, 3).

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Most plant species respond differently to radiation quality (color or wavelength) and the amount of it (photon flux density PPFD or irradiance-) manner, and combinations of both, which represents a key factor in the interference between crops and weeds. The quality and quantity effect of radiation is combined with environmental shadow component that produces a characteristic radiation spectrum under the canopy of plants. Leaves absorb photons in the blue and red spectrum of photosynthetically active radiation (PAR), while absorption in the green and especially in the region of far-red is weaker and much of these photons reflected as diffuse radiation (radiance). Precursors to demonstrate the importance of the ratio between red and far-red (R/FR), as a fundamental component of the shadow among neighboring plants, early uptake of this signal by internodes and its relationship to the foliage density, which modulates the amount of radiation also demonstrated that plants can detect the presence of neighboring plants, long before they are shaded (4, 5).

Weeds are a major constraint on the cultivation of *Zea mays L.*; an annual yield loss up to 30 % is estimated, due to the damage done to the same crop (6). Therefore, they are a problem in production, mainly in early stages of crop development. Moreover, the critical period for weed control in crops starts from the early growth of it; in the case of the culture under study, the critical period is when the third or fourth leaf appears on the plant (7).

In this case the resource, light of ratio between red and far-red (R/FR) plays an important role in detecting weeds as neighboring maize plants at an early stage of plant growth (7, 10, 11). Crops can "see" these neighboring plants because of the difference reflected in the ratio of red and far-red (R/FR). When the ratio between red and far-red (R/FR) in reflected light is high, neighboring plants detect weeds, while a low ratio between the red and far-red (R/FR) the opposite happens (8, 9, 12, 13).

The topic has not been dealt in all its magnitude, but some studies have found that there is a reduction in root biomass and the root volume, both wheat and corn when grown in low ratio of red and the far-red (R/FR) compared with plants grown in high proportions (R/FR) (14, 15, 16). The reaction to neighboring plants is similar to the strategy of plant shadow effect; reducing the number of end grain corn plants (7, 10, 17). Since plants are capable of detecting neighboring plants at an early stage of their growth, it is vital to take this into account to carry out a good management of weed control in order to avoid yield losses during the growing season (18, 19, 20).

Because of the importance of shadow and the effect exerted by neighboring weeds in corn growth and that most works do not include the quality component, that is, the radiation wavelength, the present study aim was to determine the effect of neighboring weeds and competition for light on corn plants in development early stages.

MATERIALS AND METHODS

Experiments were performed in a controlled environment in growth chambers of the Plant Agriculture Department, University of Guelph, Ontario, Canada, using cultivar CG108 x CG102 (hybrid of *Zea mays* L., University of Guelph).

Vegetative states used are below:

VE-Emergency
V1-neck of the first leaf (the first leaf is seen always it has a rounded tip)
V2-neck of the second leaf is seen
V3-neck of the third leaf is seen
V4- neck of the fourth leaf is seen

Experiment I. Effect of weeds in early development stages of the crop. The corn seeds were moistened with plain water for 24 hours before planting. A seed per pot was sown in plastic cups 355 ml (Dart Container Corporation, Mason, MI, USA) with 8 cm diameter and 10 cm to 2 cm deep. Plastic cups were placed in cylinders (diameter 8 cm, height 18 cm, 18 cm Natural modified cylinder 1 L, Consolidated Bottle Co., Toronto, ON, Canada). Thereafter the cylinders were placed in pots of 25 cm diameter (height 19 cm, 6 L, Airlite Plastics Company, Omaha, NE, USA) (Figure 1).

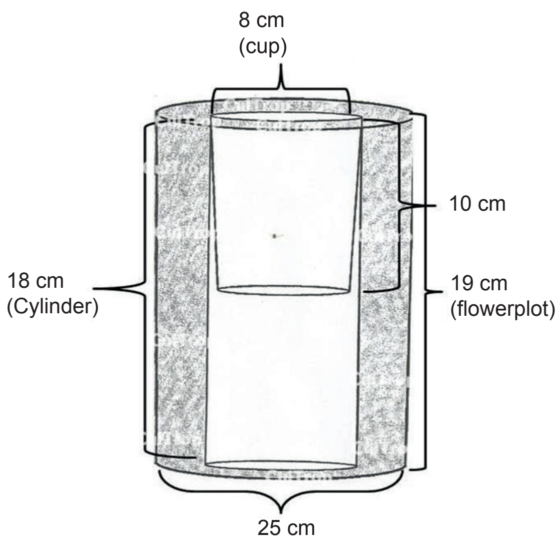
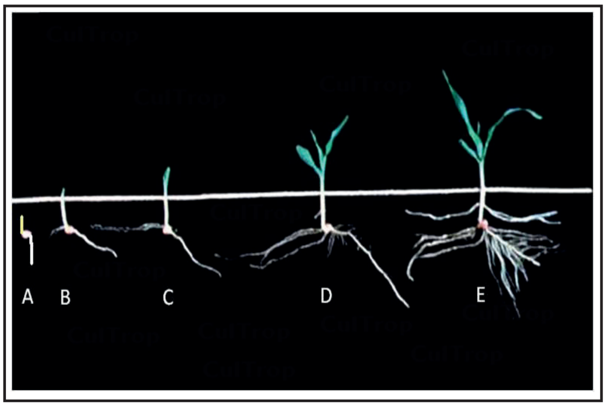


Figure 1. Schematic diagram of an experimental unit

In weed-free treatments and with weed the pots and plastic cups were filled with Turface® 100 % calcined clay with particle size between 2,5 and 3,5 mm (Turface MVP® Profile Products LLC, Buffalo Grove, IL, USA). In the case of treatment with weed the area around the plastic cup was planted with ryegrass (*Lolium perenne* L. cv. Feast III) (two to three weeks before planting corn seed).

Experiments were irrigated daily and fertilized with a nutrient solution containing N, P, K, Ca, and Mg and micronutrient supplements (21).

To prevent the shadow, weeds were cut when they exceeded pots. Eight plants were extracted at random in five different stages of development between the mesocotyl stages (A) (B), (C), (D) and the fourth leaf emission (E) (Figure 2). In total 40 plants were extracted per treatment.



A: mesocotyl phase (before plant emergency)
B: leaf appearance first phase
C: leaf appearance second phase
D: leaf appearance third phase
E: leaf appearance fourth phase

Figure 2. Early development phases of maize plant growth

The relative humidity ranged from 60-65 %. Irradiation was provided by the use of Sylvania cool white fluorescent tubes interspersed with tungsten 40 Watts bulbs, for a photosynthetic photon flux density (PPFD for its acronym in English) of 250 µmol m^{-2} s^{-1}.

Experiment II. Different densities effect in early crop development.

In order to study the effect of different densities in the early development of maize plants it was carried out a preliminary experiment to create three treatments with different light densities, under the same conditions of growth chamber as explained in the above experiment. Seeds were planted at a depth of 2 cm in white containers (Ray Leach Cone-tainer Trays, Stuewe and Sons, Inc., Tangent, OR, USA.) covered with a layer of rock wool (Grodan; Grodania A/S, DK 2640 Hedelusene, Denmark) at the bottom, and then were filled with Turface®. These containers were placed in plastic trays (Ray Leach Trays Cone-tainer, Stuewe and Sons, Inc., Tangent, OR, USA) (Figure 3), with different distances to create three different treatments. In the first treatment to be considered as a treatment of low density (R/FR 1,3 and 145±11,3 PPFD), nine plants were planted in a tray to 25 cm between plants. Treatment of average density consisted on 28 plants and 8.5 cm between plants 17 (R/FR 1,1 and 106±11,5 PPFD), while high density treatment consisted on 81 plants to 4,25 cm between plants (R/FR 0, 7 and 76±12, 7 PPFD). The distance between plants in all treatments was covered with white containers, which are filled with Turface® (Figure 4).

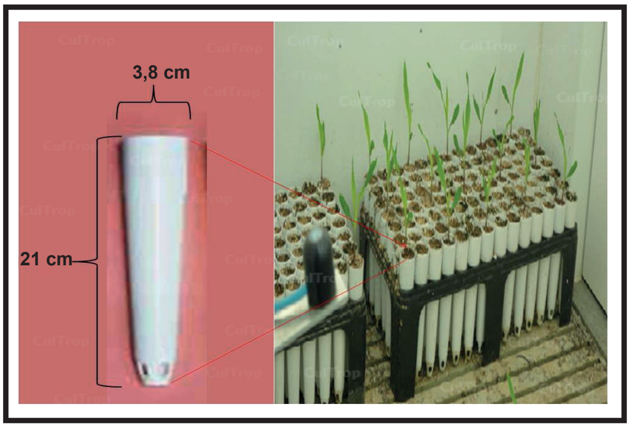
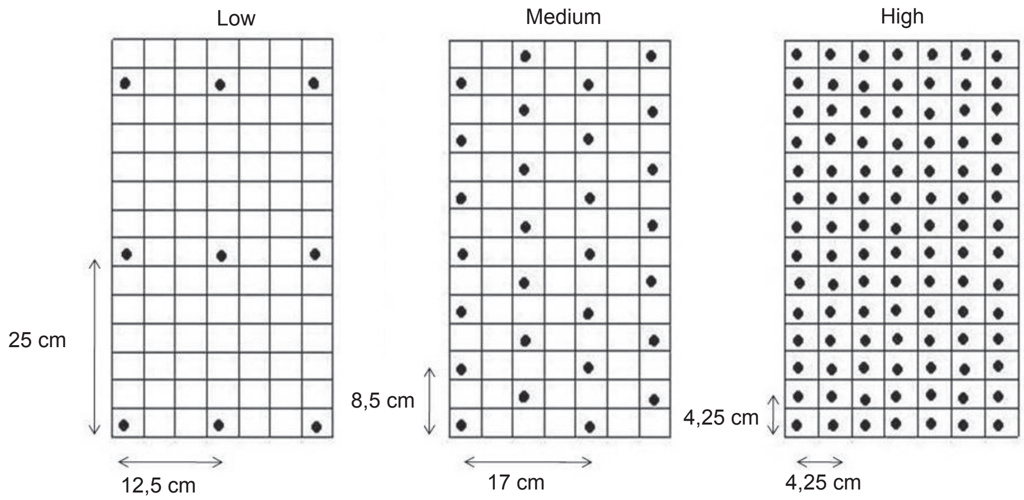


Figure 3. Schematic diagrams of white recipient and plastic trays

Plastic trays, including white containers were placed in a plastic box (the same size as the trays) filled with water, to prevent drying. The containers were irrigated twice daily using a watering can and covered with a black plastic tray to seed germination to maintain moisture. After plant emergency, seedlings were watered once days with a micronutrient supplement (21). This system ensured that there was no competition between corn plants by water or nutrients. 15 seedlings were extracted per treatment when plants were in the V4 stage (vegetative stage of the plant when the fourth leaf appears) to have different measurements.



Low density (9 plants per tray) (R/FR 1,3 and 145±11,3 PPFD); medium density (28 plants per tray) (R/FR 1,1 and 106±11,5 PPFD); high density (81 plants per tray) plants (R/FR 0,7 and 76±12,7 PPFD)

Figure 4. Experiment scheme with different used densities

Morphological measurements

In both experiments the following were measured: stem length (cm), number of crown root (No.), stem diameter (mm), root biomass (g), stem biomass (g) and stem-root ratio, these variables were measured to find the differences in the early development of corn plants. Morphological characteristics were evaluated once removed plants.

The length was measured with a ruler; stem diameter, using a vernier caliper (Mastercraft), but this is only measured from the second end of the leaf on; biomass was obtained by drying the fresh plant material in an oven (80 ° C) for three days. The material was weighed on an analytical balance (Mettler Toledo).

Light measuring

The amount of light (PPFD) and the quality of light (R/FR) were measured once a day during the experimental period. The PPFD was measured 10 cm above the maize seedlings using a quantum dot radiometer (LI-190SA; LI-COR Biosciences, Lincoln, NE, USA), with a cosine-corrected optical fiber sensor. The red/far-red ratio (R/FR) of the reflected light was measured regularly during the period with a sensor R/FR (SK R 110; Skye Instruments, Llandrindod Wells, Powys, UK). In the first experiment the reflectance (ability of surfaces to reflect light) was evaluated at 10 cm above the Turface® or weeds in four randomly selected positions in each treatment. The R/FR ratio was measured after planting corn seeds in plastic cups and before each harvest. The R/FR, relationship differs between treatments. The reflected R/FR relationship stage treatment and is presented in Table I.

Table I. Red/Far Red average ratio in the growth chamber for harvest stage

	Treatments	
	Free of weeds	With weeds
Sampling 1	1,39 ± 0,015	0,40 ± 0,015
Sampling 2	1,34 ± 0,023	0,45 ± 0,022
Sampling 3	1,36 ± 0,025	0,45 ± 0,022
Sampling 4	1,35 ± 0,039	0,45 ± 0,008
Sampling 5	1,33 ± 0,008	0,29 ± 0,022

Experimental design and statistical analysis

All experiments were designed as random blocks. In these experiments, repetitions environments were defined as the growth chamber in time and were combined for analysis. The first experiment was repeated five times. The second experiment was repeated three times. All statistical analyzes were performed in SAS 9,1 (SAS Institute, Cary, NC, USA), with a type 1 error rate established in α = 0,05. Statistical Shapiro-Wilk test was used to test the normality assumption. It did not require transformation before statistical analysis. Significant differences among treatments were analyzed using the Tukey test.

RESULTS AND DISCUSSION

Experiment I. Weed effect in early development stages of the crop

The stem length in the first harvest after 48 hours, and it differed among treatments, although it had not yet sprouted on the soil surface. Stem length of seedlings grown in weed-free conditions was significantly higher (1, 39±0, 239 cm) seedlings grown in conditions with weeds (1, 13±0, 259 cm) (Table II and Figure 5), while there was no competition of roots, because weeds made no contact with seedlings roots.

As from the second sampling, the opposite effect was visible in plants; stem length in seedlings grown under conditions with weeds was significantly greater than the stem length of cultivated plants in weed free conditions. Most stem length for cultivated plants in conditions with weeds remained visible during the remainder of the experiment, which can be explained by the effect of interference produced on seedling weeds.

The length of the last mature leaf from the neck was visible from the V3 stage (vegetative stage when the third leaf appears) onwards, and had similar results for stem length; neck leaf plants grown in conditions with weeds was significantly greater than the neck of the leaf grown plants weed-free conditions (Table II). Since both, the stem length and neck leaf are characteristic of the plant height, no differences are expected, but in this specific case if they were obtained by interference of weeds had with seedlings.

Contrary results were visible to the stem biomass. Biomass stem was higher in seedlings grown in free conditions weeds at all stages of harvest, except for V1 (vegetative stage when the first leaf appears) stage, although stem length was greater when seeded in conditions with weeds, from V1 stage onwards. This greater biomass is in line with the stem results of diameter seedlings. Stem diameter, measured from the V2 stage, it was higher in plants grown in weed-free conditions in V3 and V4 stages. When the stem diameter was compared with stem length (Table II), we observed that the stem diameter was able to weed smaller than weed free conditions, even on the same stem length. In step V2, no difference was found in the root biomass. Besides root biomass had the same results as the aerial biomass. With respect to the cultivated plants in weed free conditions obtained a higher root biomass to seedlings grown in conditions with weeds at all crop stages. The root-stem ratio did not differ among treatments, except for the V1 stage, where the ratio root/stem, was significantly higher for plants grown under weed-free conditions. The number of crown roots, was first visible at the V3 stage, developed in line with the root biomass. In weed free conditions seedlings had produced a significantly greater number of crown roots in conditions with weeds. At step V3, the number average crown root behaved greater in weed free conditions compared with weeds conditions. This effect was even greater in the V4 stage in weed-free conditions compared to the conditions with weeds.

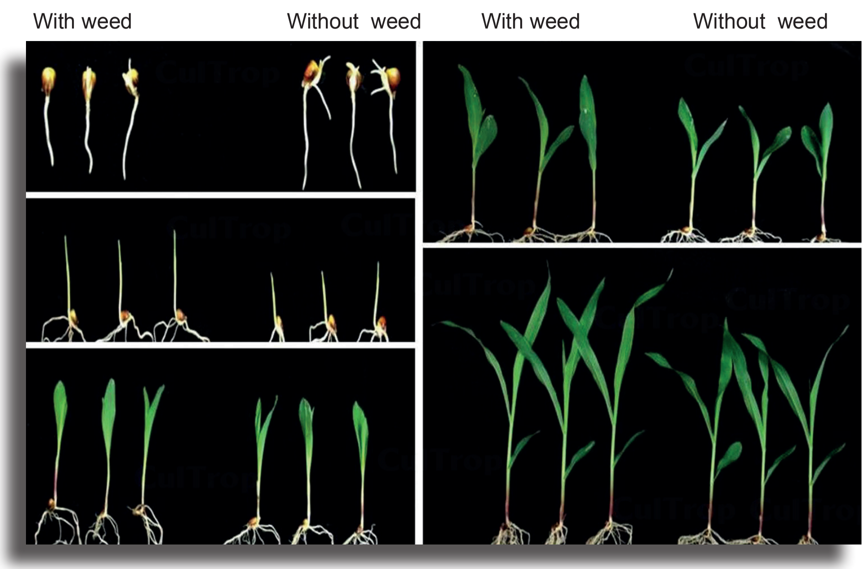
In general, the growth of corn grown under weed growth, resulted in reduced plant growth to 48 hours after seeding, compared to plants grown in weed free conditions. After 96 hours (VE stage, emergency-germination) the opposite effect was visible as it was a reaction to try to avoid the shadow in plants by the action of weeds. This resulted in higher and thinner plants when grown in conditions with weeds. Moreover, the root growth was also affected, resulting in lower root biomass and the number of roots at the crown. This result was similar to that found by other authors (16, 17) who noted that in the same conditions the plants have less number of roots at the crown, low total volume of roots and lower root biomass when grown under conditions with weeds, the opposite occurring when grown in conditions free of weeds.

Plants that were planted under conditions of weed growth were with the smallest stem diameter due to the action that made weeds and as a result there was an avoidance reaction by shadow results that match various authors (7, 9, 13) although these studies were carried out under greenhouse and field conditions, respectively, and plants were removed from the V4 stage onwards, and in the case of this research will only be conducted until the V4 stage, confirming that in early development stages seedling weeds also exert great influence on their growth and development.

Regarding the root-stem ratio there was a decrease when plants were sown with weeds confirming studies done to date (8, 9), where results were also obtained in the root-stem decrease in plants sown under the weed effect, although results were recorded after the V4 stage. Except for research where all observations were conducted with plants in V4 stage or more (16), other studies have been conducted on the effect of the ratio R/FR plant before step V4; although in this study it was found that the reaction of shadow evasion on corn plants produced in conditions with weeds is already visible from the V1 stage, even without root competition.

Table II. Characteristics of five harvest averages done in with and without weeds conditions

	Treatments	Stem length (cm)	Stem diameter (mm)	Last mature leaf length since its neck (cm)	Root biomass (g)	Stem biomass (g)	Root stem	Roots of the crown (no)
Harvest 1	without weeds	1,39 ± 0,239	-	-	14,64 ± 3,017	4,85 ± 1,003	3,01 ± 0,116	-
	with weeds	1,13 ± 0,259	-	-	12,54 ± 3,497	4,39 ± 0,821	2,86 ± 0,292	-
	Value p	< 0,001	-	-	0,012	0,049	0,360	-
Harvest 2	without weeds	5,30 ± 0,786	-	-	45,95 ± 7,239	20,19 ± 2,753	2,28 ± 0,157	-
	with weeds	6,50 ± 0,874	-	-	39,97 ± 7,597	19,99 ± 2,898	2,00 ± 0,113	-
	Value p	< 0,001	-	-	0,002	0,775	0,027	-
Harvest 3	without weeds	9,33 ± 0,694	3,04 ± 0,213	-	58,05 ± 7,826	40,72 ± 4,671	1,43 ± 0,068	-
	with weeds	9,87 ± 0,703	3,02 ± 0,226	-	53,51 ± 8,577	37,94 ± 3,583	1,41 ± 0,059	-
	Value p	< 0,001	0,713	-	0,031	0,010	0,743	-
Harvest 4	without weeds	16,38 ± 2,014	3,42 ± 0,307	5,58 ± 0,659	73,42 ± 10,934	75,99 ± 7,758	0,97 ± 0,074	2,31 ± 0,125
	with weeds	19,51 ± 2,597	3,10 ± 0,265	6,56 ± 0,751	67,33 ± 9,807	71,66 ± 8,548	0,94 ± 0,058	1,94 ± 0,217
	Value p	< 0,001	0,003	< 0,001	0,022	0,038	0,585	0,024
Harvest 5	without weeds	36,10 ± 3,350	4,96 ± 0,345	11,93 ± 0,960	117,63 ± 15,407	249,18 ± 44,509	0,48 ± 0,053	5,78 ± 0,157
	with weeds	41,02 ± 6,829	4,40 ± 0,365	12,71 ± 0,900	108,29 ± 12,465	212,34 ± 43,462	0,52 ± 0,060	5,03 ± 0,120
	Value p	< 0,001	< 0,001	0,001	0,010	0,001	0,383	< 0,001



Up left: mesocotyl stage, left medium: first leaf stage; down left: second leaf stage, up right: third leaf stage, inferior right part: fourth leaf stage

Figure. 5 Seedling images in each harvest stage, cultivated with (I) and without weeds (D)

What is still not explained the difference in the growth phase mesocotyl corn on top. The mesocotyl was greater when planted under weed-free conditions when grown with weeds, while this changed just 48 hours later producing the opposite effect. This means that the seedling is able to visualize the difference in the ratio R/FR in the first 48 hours of plant growth. The question remains why results were opposite after the plant emerged as both stages had no root competition and the difference between the ratio R/FR was the only difference that occurred in the experiment, so that should conduct research related to this topic to learn why the plant had this response.

Experiment II. Different densities effect in the early crop development

Stem length of grown seedlings in different densities was significantly different in the V4 stage. Grown seedlings with a high density were higher (42,70 cm) plantlets grown at low density (39.68 cm) or medium density (40,37 cm) (Table III). Stem length also differ significantly between the densities to the neck of the second leaf. Plants were planted to high densities lengths had significantly higher (12,90 cm) plants that were planted in medium density and low, but there was difference among plants grown under these densities. Seedlings planted in low densities had leaf neck significantly lower (10,19 cm) than plants grown in medium densities (10,91 cm). The opposite was found for stem diameter, where seedlings were grown at low densities had greater stem diameter (5,04 mm), and seedlings grown at high densities had the lowest stem diameter with 4,61 mm.

Seeded plants with an average density averaged had a stem diameter of 4,81 mm, intermediate values between low and high densities. These results are consistent with those of root biomass and aerial biomass, which were higher for seedlings planted at low density and low for seedlings planted densely. Planted plants in medium density did not differ significantly in the amount of root biomass in plants grown at low densities, while the stem biomass was not different between plants grown in low or high densities.

When corn plants are cultivated with a high density, it was obtained as a reaction result by shadow avoidance of weeds, due the competition for light, since it was the only limiting factor, even when plants were older to V4 stage. At low densities, there was the same effect as happened with the previous density, due to the fact that there was competition for light and the ratio R/FL was higher than when sown under high densities.

The effects of planting density has on the final yield of maize are known since time ago, but the fact that planting density effects are already visible in the V4 stage are not known yet. However, it has been confirmed that this avoidance reaction by shadow is visible before canopy closure (22). Our research is in agreement with other studies where it was found that a high density planting resulted in a shade avoidance reaction by (13, 23). This avoidance by shady means lower final yields in corn, so it is important that avoidance effects by shadow is minimized, as this will result in higher yields (24). This contrasts with previous studies on densities in corn, which indicated that a high density of planting will provide a higher yield varieties with high yield potential (20, 25, 26).

Table III. Average results measured characters to 15 seedlings in different densities (low, medium or high density) including the standard error and P value

	Treatments			
	Low	Medium	High	*P-value*
Stem length (cm)	39,68 ± 4,477 b*	40,38 ± 3,676 b	42,70 ± 4,822 a	0,003
Stem diameter (mm)	5,04 ± 0,477 a	4,81 ± 0,342 b	4,61 ± 0,277 c	< 0,001
Neck 2nd leaf (cm)	10,19 ± 0,820 c	10,91 ± 0,903 b	12,90 ± 0,867 a	< 0,001
Biomass, roots (g)	165,26 ± 27,236 a	164,87 ± 29,198 a	135,11 ± 18,300 b	< 0,001
Biomass, stem (g)	249,86 ± 36,820 a	245,43 ± 31,639 ab	229,05 ± 30,409 b	0,034
Root-stem	0,67 ± 0,097 a	0,68 ± 0,116 a	0,60 ± 0,086 b	0,003
Roots, crown (no)	6,25 ± 1,016 a	5,84 ± 0,767 a	5,16 ± 0,515 b	< 0,001

* Mean with different letter in a random variable and the treatment differ significantly (α<0,05)

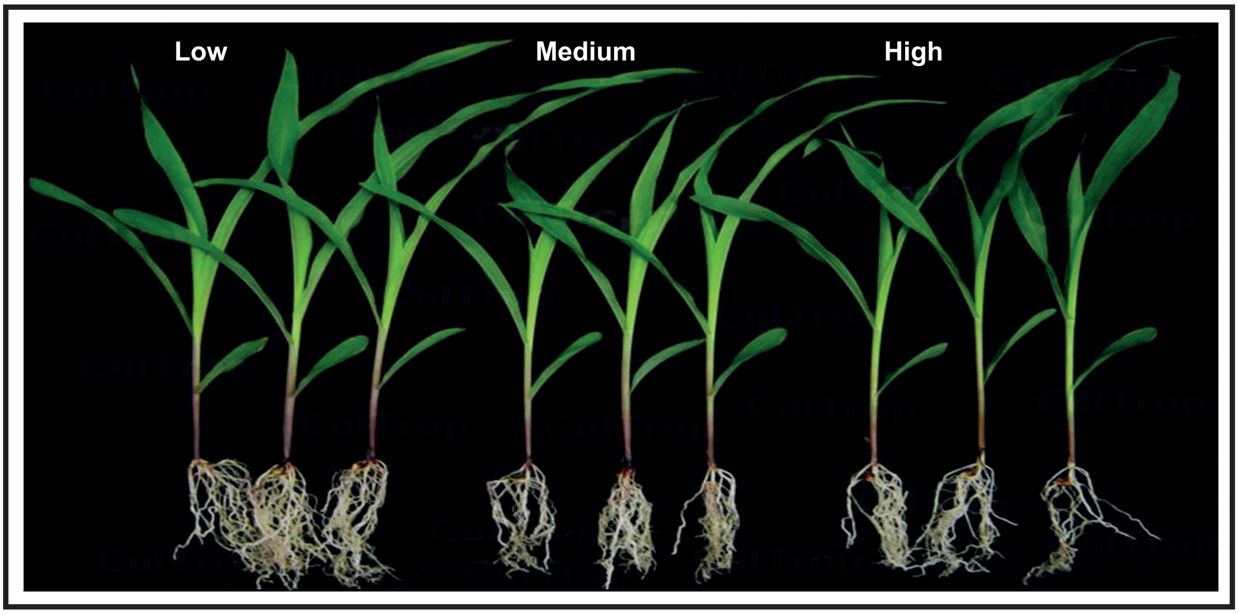


Figure 6. Plants of the three planning densities used (low, medium and high). Seedlings are at the V4 stage

However, regarding the proportion root-stem hardly differed from biomass as plants grown at high densities had a lower proportion root-stem plants planted in low and medium densities. The same was found for the number of crown root was 6, 25 and 5,84 in plants grown in low and medium densities, respectively, substantially similar, and was lower in seedlings grown under high densities (5,16 estate).

In images of Figure 6 it is clearly visible that the root volume is smaller when seedlings are grown at high densities. Besides the difference in the volume of the root, they are also visible differences in the length and diameter of the stem.

The shadow avoidance reaction by plants is probably directed by hormones such as auxins (25, 26), gibberellins (27), ethylene (27, 28, 29) and brassinosteroids (26, 28).

A low ratio R/FR auxin levels in higher plants, may be one of substances responsible for elongation, and regulating the different stages of plant growth; for example, the metabolism of the cell wall and cell elongation (26, 28). In addition to stem elongation, auxins are also responsible for producing smaller roots as auxins are transported from young leaves down through the stem reaching the roots (25, 26).

When plants are grown at low densities the ratio R/FR auxins distribution will change, resulting in a smaller amount of auxin that will reach leaves, and a reduction of root growth (26).

Moreover, the seed germination and plant growth are regulated by gibberellin, which will be affected by the phytochrome, light receivers; for example the quality of light (28). These authors suggested that phytochrome controls stem elongation in plants is through the regulation of a gibberellin. A study found that gibberellin plays an important role in responding to the low ratio R/FR and blue light, as mutants deficient in snuff gibberellins did not respond to different R/FR proportions while wild types did (27).

Gibberellins affect other regulating hormones such as vegetable, ethylene, which requires gibberellins to produce a shade avoidance reaction (26). Low ratios R/FR lead to an increase in ethylene plant, which is similar phenotypes to those of plants having avoidance reactions by shadow (26, 28) Deficiency also ethylene mutants snuff made they were not able to compete for light while plants snuff wild type were able to compete. The elongation in plants is the result of low level that they produce ethylene. This hormone is probably regulated by light signals such as R/FR proportions, resulting in the shade avoidance reaction by (28). As indicated above plant hormones are the cause of differences in the growth of seedlings in our experiment, either weed free conditions or weeds and under different densities. Hormones are responsible for growth, for example, stem elongation and thereby the diameter thereof, but also for the number root and crown root respectively.

CONCLUSIONS

According to these results it can be concluded that the morphology of the plant is affected by neighboring plants, whether weeds or plants of the same species; further that plants react in early stage of growth since the first reaction was visible at 48 hours after seeding.

After 96 hours the first reaction characteristics to avoid common shadow were visible in seedlings planted in conditions under weeds, stalks were taller and had a shaft diameter smaller than the plants that were planted in free conditions weeds. Since plants are able to visualize the surrounding weeds in its early development, it is important to consider the control of weeds in early growth stages of maize, by the reaction to avoid the shadow due to weeds which cause lower yields.

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