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GREEN BIOMASS YIELD IN SUNFLOWER AS A FUNCTION OF STOCKING DENSITY

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Abstract: Sunflower has forage potential. The objective of this study was to determine in sunflower: the effect of PD on 1) the days to occurrence of phenological stages, plant height dynamics, green biomass and dry biomass production: 2) the dynamics of leaf:stem ratio and c) if plant height can be an appropriate estimator of biomass. The study was conducted in Montecillo Mex. (19 ° 29' N, 98° 53'0 and 2,250m altitude) of temperate climate (Cw) and clay loam soil Planting of sunflower cultivar "Victoria Mejorado" was carried out on May 20, 2022, with 100-100-00 of The treatments were three stocking densities (PD): 2.5plants m^{-2} (50*80 cm): 5 plants m^{-2}(25*80cm) and 7.5 plants m^{-2} (33*40 cm). The experimental unit was 4 x3.2 m . The experimental design was randomized blocks with four replications. The results indicate that the days to occurrence at phenological stages were not affected by stocking density. In contrast, the dynamics of height, the production of both green and dry biomass and the leaf:stem ratio were significantly changed by stocking density. Plant height may be an appropriate estimator of biomass production in sunflower.
Keywords: height, leaf:stem ratio,, matter weight, estimation model.

INTRODUCTION

In Mexico, in addition to grasses and legumes, there are other species with forage potential, such as sunflower, due to its protein content in both leaves and stems. In addition, sunflower can thrive in water-limited regions (Escalante and Linzaga 2002). As the plant grows, the cellulose increases and the protein and digestibility content decreases (García, 2004). The management of stocking density (PD) is one of the most recommended agricultural practices to achieve an increase in crop production, because with the appropriate PD a better use of soil, solar radiation, water and nutrients can be achieved. Increasing density reduces biomass and yield per plant. However, biomass and seed yield per area are higher (Escalante 1999 and Aguilar *et al.* 2002). Vázquez (2003) and García (2004), in a study with sunflower line 58, for forage that is well accepted by cattle, conducted a proximate analysis of the grain and found that on average it contains 32% of ethereal extract (crude fat), 2% of crude fiber, 11% of crude protein, 18.% of ash and 41% of free nitrogen extract (carbohydrates). Escalante *et al.*(2008) report that with DP of 75,000, 100,000, 125,000 and 150,000 plants.ha^{-1}, they found that the leaf: stem ratio was >0.7 and that with 150,000 plants.ha^{-1} the highest forage production of 9.5 t.ha^{-1} was achieved.The objective of this study was to determine in sunflower: the effect of PD on 1) the days to occurrence at phenological stages, plant height dynamics, green biomass and dry biomass production: 2) the dynamics of the leaf:stem ratio and c) whether plant height can be an appropriate estimator of biomass.

MATERIALS AND METHOD

The study was conducted in Montecillo, Mexico (19 ° 29' N, 98° 53'0 and 2,250 m altitude) with a temperate climate (Cw according to Garcia, 2005). The results of the soil analysis where the experiment was conducted indicate that it is a clay loam soil, alkaline (pH = 8.4), 2.7 dSm^{-1}), medium organic matter content (3.9%), moderate N-NO_3 (45 ppm) and moderately low in P (14 ppm). Sunflower cultivar "Victoria Improved" was sown on May 20, 2022, in furrows of80 cm spacing It was fertilized with 100-100-00 NPK. Nitrogen was applied twice; 50% before planting and the rest at the first weeding. The treatments were three stocking densities (PD): 2.5 plants m^{-2} (50*80 cm): 5 plants m^{-2}(25*80cm) and 7.5 plants m^{-2} (33*40 cm). The experimental unit was 4 x3.2 m . The experimental design was randomized blocks with four replications

VARIABLES RECORDED

Climate: The maximum mean temperature (TMAX), minimum mean temperature (TMIN) and the sum of rainfall (PP, mm) were recorded. the days to occurrence of phenological stages such as: emergence (Ve), R5 (when the flower head presents exposed and turgid ligulate flowers) and physiological maturity (R9, back of the yellow flower head) according to the keys of Schneiter and Miller (1981).To record height (cm, ALT)), fresh matter (green biomass, BV) and dry matter (BIO) of stems, leaves, capitulum and total (gm^{-2}), four plants per experimental unit were sampled at 36, 56, 90 and 120 days after planting. Dry matter (DM) was obtained by placing the material in a forced air oven at 80°C for 72 hours. Fresh or green matter (FM) was estimated using the model MF=MS*3.6. This coefficient resulted from a regression between FP and PS, with data from different sunflower cultivars presented in Tomich *et al*. (2003b). In addition, the ratio of leaf weight/stem weight (RHT) and total weight (BT) to plant height (ALT) was calculated. Analysis of variance (ANDEVA), Tukey's test and regression analysis were applied using the SAS *9.0* package *(SAS, 2003)*

RESULTS AND DISCUSSION

PHENOLOGY AND CLIMATE ELEMENTS

Thus, during the sowing to emergence stage, the average Tmax and Tmin were 31 and 7 °C, from emergence to flower head emergence (R1) 28 and 9 °C, and from flower head emergence to the beginning of flowering 27 and 9 °C, respectively. During the stage from the beginning of flowering to physiological maturity, the temperature reached a maximum of 25 °C and a minimum of 6 °C. Seasonal precipitation was 394 mm. No changes were observed in sunflower phenology due to the effect of stocking density. Thus, the period from sowing to emergence lasted 12 days. From emergence to flower head emergence (R1) was 44 days, from flower head emergence to beginning of flowering (R5) 28 days (in sum from sowing to R5 72 days) and the period from beginning of flowering to physiological maturity lasted 33 days. Thus, the biological cycle was 117 days.

DYNAMICS OF HEIGHT, DRY AND FRESH WEIGHTS

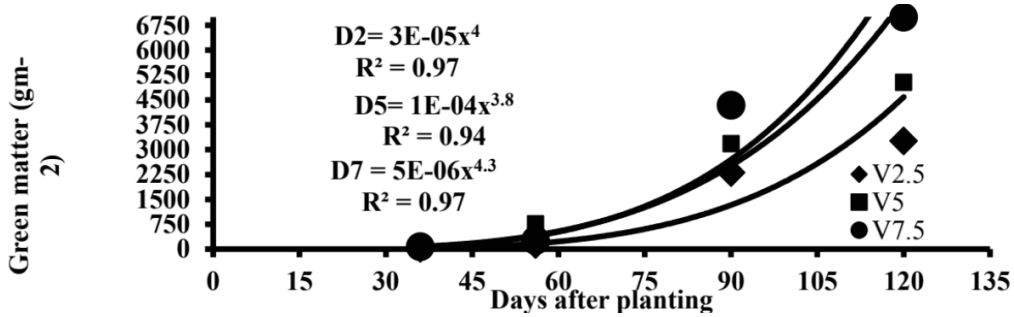
The ANDVA showed significant changes (Table 1) for plant height and biomass on a dry matter basis (BIO).

Dynamics of height, dry and fresh weight of sunflower cultivar Victoria Mejorado, the beginning of flowering was at 72 days. Montecillo, Mex. summer 2022.

DP	36ALT	56ALT	90ALT	120ALT	36BIO	56BIO	90BIO	120BIO
2.5	28	90c	200bc	203c	7c	122c	642c	907c
5.0	27	102b	220b	225b	14b	213b	884b	1396b
7.5	28	139a	231a	253a	21a	340a	1222a	1923a
TUKEY0.05	NS	6**	20**	20**	2**	22**	95**	90**

DP= population density, plants m^{-2}; ALT= plant height; BIO= biomass or dry matter weight. In columns values with similar letter are statistically equal.** probability of F=0.01.

Figure 1 presents the dynamics of green biomass (fresh weight, BV), where it is observed that this increases as the sunflower growth cycle progresses, presents differences between DPs and increases as the DP increases. The fitting model of the curves was the potential ($Y= a +b X^p$). Thus, the maximum BV production is about 7 kg m^{-2}, which includes BV of stem, leaves and flower head. However, as it is suggested to harvest for forage before flowering 72 days, the BV would be close to 1.5 kg m^{-2}). An advantage is that at this cutting day more plantings could be made before the frost period.



Dynamics of green biomass production based on fresh matter (forage) weight of the sunflower cultivar Victoria Mejorado, the beginning of flowering was at 72 days. Montecillo, Mexico, Summer 2022.

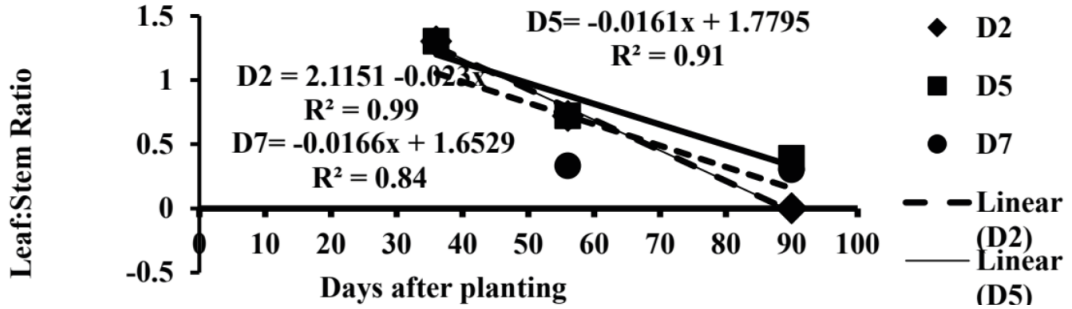
RATIO LEAF; STEM

The dynamics of the leaf: stem ratio (LTR) evaluated from 36 to 90 days after planting, shown in Figure 2, indicates that it was highest on D5, followed by D2 and D7, which did not show differences. In general, a linear trend is observed (Y=a + bx), in which, as crop development progresses, it tends to be low, as indicated by the negative slopes (Figure 2). Thus, at the time of flowering we would have a HT ratio of 0.8, which indicates greater weight of the stem in relation to that of the leaf. In summary, in cutting for forage, D5 would have a higher production with 7 kg m^{-2} and an H:T ratio of 0.8. A similar value is reported by Escalante *et al.*(2008).

TOTAL BIOMASS TO HEIGHT RATIO

With data up to 90 days, when studying the degree of relationship between total biomass (BT) and plant height (ALT), a high relationship was found (R^2= 0.94) with an estimation model BT=175 + 4.5 ALT. This indicates that crop ALT may be an appropriate estimator of BT. Similar trends were reported in native maize cv. Azul by Escalante *et al.* (2017).

Dynamics of the leaf: stem ratio (LTR) of the improved forage sunflower cv. Victoria. Flowering initiation was at 72 days. Montecillo Méx. Summer 2022.



CONCLUSIONS

Days to occurrence at phenological stages were not affected by stocking density. In contrast, height dynamics, production of both green and dry biomass and the ratio Leaf:Stem showed significant changes by stocking density. Plant height can be an appropriate estimator of biomass production in sunflower.

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