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Full Length Research Paper

Root-promoting substances enhance Sugarcane's drought tolerance

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Sugarcane (*Saccharum* spp) is an expanding culture for the production of bioethanol around the world which requires certain practices to improve its productive performance at the different ecosystems. This work's aim is to evaluate the initial Sugarcane growth and drought tolerance through the application of biostimulants. For this purpose an experiment was conducted in a greenhouse using completely randomized design. Prior to planting, the cuttings were treated with: T_1 - Water; T_2 - Indolebutyric Acid (IBA); T_3 - Boron + Zinc; T_4 - Tryptophan; T_5 - Kymon Plus® + Potamol®; and T_6 - Stimulate®. Morphological analysis was performed at 40 and 124 days after planting (DAP) to assess the plant initial growth. The biostimulants effect on drought stress mitigation was evaluated at 120 DAP, after 3 days of suppression irrigation. The IBA and Stimulate® application delivered higher growth rates and biomass accumulation. When compared to Control treatment, the application of Ubyfol® and Stimulate® provided higher photosynthesis in the absence of drought stress and had higher PSII effective quantum yield even when plants were under drought stress. The application of Stimulate® enabled plants to maintain higher photosynthetic, transpiration and stomatal conductance rates under moderate drought stress.

Key words: Drought stress, photosynthesis, *Saccharum* spp, transpiration

INTRODUCTION

Sugarcane (*Saccharum* spp.) culture has great economic, social and environmental importance due to its large planted areas and capability to generate the raw material source for sugar and ethanol agribusiness (Ferreira Júnior et al., 2012). The productive performance of sugarcane is dependent on several factors, including the use of growth regulators (Serciloto, 2002; Silva, 2010; Ayele et al., 2014).

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Table 1. Chemical and physical characteristics of the soil.

pH	P	K	Na	Al	Ca	Mg	Fe	Mn	Zn	Cu	V	m	CTC	SOM
(H_2O)	---- mg kg^{-1} ----			------ $cmol_c$ dm^{-3} -----			-------- mg kg^{-1} --------				---------- % ----------			dag kg^{-1}
5.3	12	28	11	0.26	1.8	1.2	267.5	4.07	0.6	0.37	39.4	7.7	7.92	1.56

Coarse sand	Fine sand	Total sand	Silt	Clay
---------- g kg^{-1} ----------				
369	192	561	112	327

Soil textural class: sandy clay loam; SOM: soil organic matter, V: base saturation, M: aluminum saturation, CEC: cation exchange capacity, Mg: magnesium, Ca: calcium, Al: aluminum, H: hydrogen, K: potassium, P: phosphorus, Na: sodium, Fe: Iron, Mn: manganese, Zn: zinc, Cu: copper.

Recent years show an increase in the use of products known as plant biostimulants for a higher crop yield. It is already considered a common technique in crops such as Rice (Garcia et al., 2009), Cotton (Albrecht et al., 2009), Soybean (Bertolin et al., 2010), Corn (Santos et al., 2013) and Sugarcane (Serciloto, 2002; Ayele et al., 2014). These substances used both in-furrow and as foliar application in sugarcane, have increased yield from 6% to 21%, with response magnitude non-dependent neither from cultivars nor from planting environments (Silva, 2010; Silva et al., 2010).

The growth regulators or bioregulators have broad applicability in numerous crops and are similar to plant hormone substances (Albrecht et al., 2011). Biostimulants can be found within the regulators category, these are mixtures of one or more bioregulators with compounds of different chemical nature such as: amino acids, enzymes, vitamins, minerals, etc. (Castro, 2006). Its definition is still evolving due to the biostimulators concept amplitude, however the European Biostimulants Industry Council (EBIC) defines it as a "substance(s) and/or micro-organisms whose function, when applied to plants or rhizosphere, is to stimulate natural processes to enhance nutrients absorption, nutrient efficiency, tolerance to abiotic stress and crop quality" (Calvo et al., 2014).

Recent studies show that the use of Stimulate® promotes greater dry matter accumulation on plant aerial parts (Garcia et al., 2009) of rice, as well as an increase in yield of ratoon sugarcane (Silva et al., 2010), and as such, a potentiator of crop performance. However no test has yet been performed to confirm if it would raise the sugarcane tolerance to drought conditions. Other root-promoting substances, such as IBA, a synthetic auxin, are widely used to improve rooting of cuttings of several species, especially for those with difficulty in rooting (Fachinello and Kersten, 1996).

Mineral nutrients, such as zinc and boron, have marked influence on tryptophan synthesis and on the transport of indole acetic acid (Goldbach et al., 2001). Tryptophan is an amino acid biosynthetic precursor of several indole substances, such as indole acetic acid (Haggquist et al., 1988). For example, in Zn-deficient bean (*Phaseolus vulgaris*), the level of indole acetic acid on the shoot tips and young leaves decreased to about 50% (Cakmak et al., 1989). In the same way, boron stimulated root growth in *Vicia Fava* L. (Liu et al., 2000) and in barley (Choi et al., 2007).

Water deficit has a strong importance in several aspects of plant growth; the most apparent effects are plant size, leaf area and crop yield reduction (Kramer, 1983). Artlip and Wisniewski (2002) divide the drought responses in four types: 1) growth limitation; 2) water loss minimization; 3) morphological adaptations; and 4) physiological adaptations. Amongst the factors influencing plants growth and development, the chemical signals, such as the hormones synthesized by the plant, were some of the most relevant.

Based on the hypothesis that biostimulants and root-promoting substances provide greater sugarcane growth during the tillering phase, even when under drought conditions, this work's aim was to evaluate the sugarcane's initial growth and drought stress tolerance under these products' influence.

MATERIALS AND METHODS

The experiment was conducted at Agrarian Sciences Center at the Federal University of Alagoas – Brazil, in a greenhouse at the geodetic coordinates 09°28'02" S; 35°49'43" W and 127 m altitude, during December 2010 and April 2011.

Before the experiment was setup, a soil chemical and physical analysis was performed (Table 1). The soil used in the experiment was air dried, disaggregated and sieved. The experiment was conducted in 20 L polyethylene pots containing 25 kg of soil. The sugarcane variety used was the RB92579.

The experiment was conducted in a completely randomized design comprising four replicas to evaluate the initial growth and drought stress effect and eight replicas for final growth evaluation. After 3 days suppressing irrigation, at 117 DAP, water deficit was imposed until leaf wilting was visible. Initial growth was evaluated 40 days after planting (DAP). Final growth was evaluated at 124 DAP.

The chemical treatments were as follows: T_1 – Control (water); T_2 - Indolebutyric Acid (IBA) at 1000 mg L^{-1}; T_3 – Boron + Zinc (Borax at 10 kg ha^{-1} + Zinc Sulfate at 20 kg $hectare^{-1}$); T_4 – Tryptophan at 7.2 kg ha^{-1}; T_5 - Kymon Plus® at 1.0 L ha^{-1} + Potamol® at 0.5 L ha^{-1}

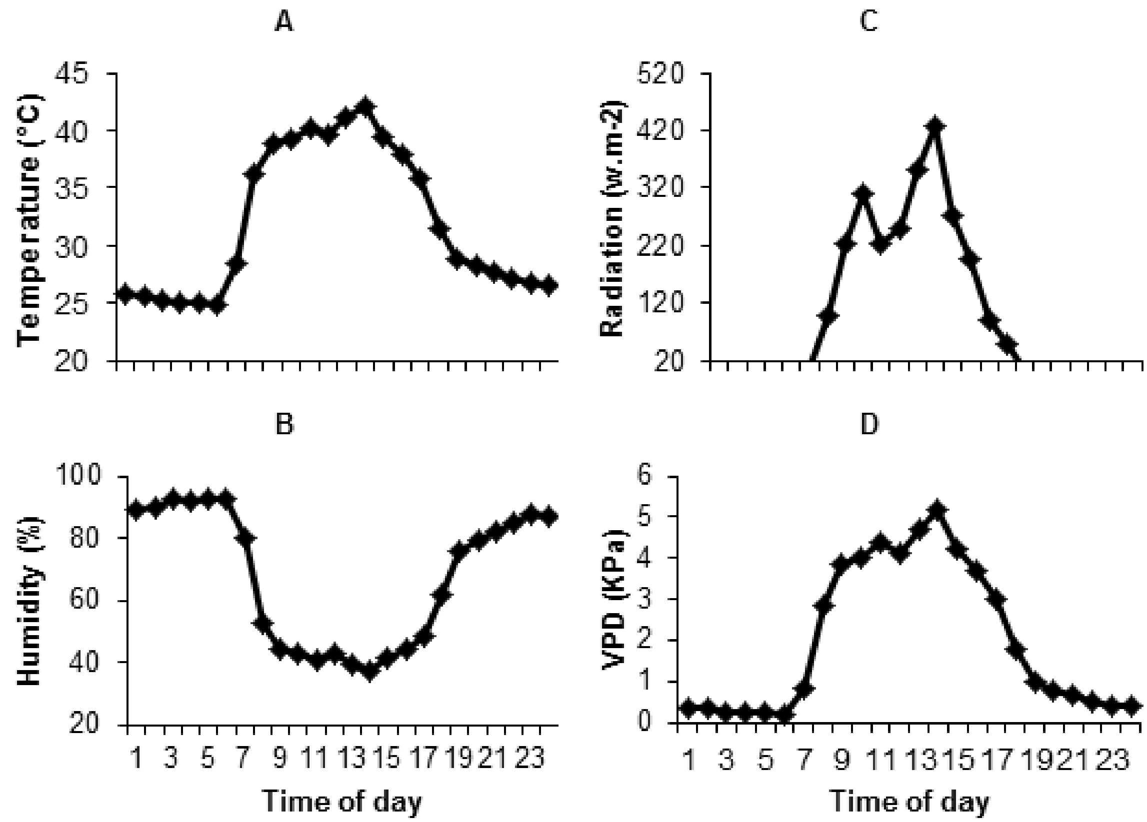

Figure 1. Temperature (A), Humidity (B), Radiation (C) and Vapor Pressure Deficit (VPD) (D) inside the greenhouse during physiological analysis 120 days after planting.

and T_6 - Stimulate® at 0.5 L ha^{-1}. Stimulate® has 90 mg L^{-1} of Kinetin, 50 mg L^{-1} of Gibberellic Acid and 50 mg L^{-1} of 4-Indol-3-ylbutyric Acid, Kymon Plus® already has 9.0% of N + 3.0% of K_2O + 11.5% of Organic Carbon + contains Polihexose and Potamol® and has 14.0% of Mo, in Potassium Molybdate form + 10.0% de K_20 + Polihexose. Commercial recommendations were used for product application based on estimating pot area and soil amount in the pots, considering a soil depth of 0.2 m and soil density of 1200 kg m^{-3}.

The products were diluted in water and sprayed onto the plant cuttings using micro sprinklers, with the exception of the IBA treatment, where cuttings were immersed for ten seconds in the IBA solution and planted just after. The IBA was dissolved in a small amount of NaOH 1 N solution, before being mixed with water.

After plantlets emergence, thinning was performed leaving only two plantlets per pot. The plants were kept under irrigation close to the field capacity up to 117 DAP with water content of 0.17 $m^3.m^{-3}$ V/V, measured with a soil moisture sensor, model SM200, connected to a HH2 moisture meter (DELTA-T Devices, Ltd., Cambridge, England). The irrigation was then suspended for 3 days to induce drought stress, when water content reached 0.015 $m^3.m^{-3}$, with visible leaves wilting on some of plants. At 120 DAP physiological analyzes were performed.

Environmental conditions were monitored during the experiment by an automatic weather station model WS-GP1 (DELTA-T Devices, Cambridge, England), located inside the greenhouse, recording temperature and relative humidity every 5 min and Solar radiation every 10 s. Based on the temperature and humidity data the vapor pressure deficit (VPD) was calculated. Environmental conditions during physiological analysis are show in Figure 1.

Two biometric evaluations were conducted, the first at 40 DAP and the second at 124 DAP. On both evaluations the following was measured: plant height (cm), number of fully expanded leaves (with at least 20% greenness), number of tillers per pot, length (cm) and width (cm) of the +3 leaf (third leaf bellow the last exposed dewlap). The leaf area (cm²) was quantified by the method described by estimating the area of individual leaves from measurement of leaf width and length (Sinclair et al., 2004). The plants were then collected, separated into leaves, culms and roots, and dried in a kiln with forced air circulation at 70°C until a constant weight was reached to obtain the dry mass (DM).

Based on morphological data from the first (40 DAP) and second (124 DAP) evaluations, a quantitative growth analysis was performed as per below (Benincasa, 1988; Cairo et al., 2008):

$$\text{Absolute growth rate (AGR)} = \frac{DM_1 - DM_2}{t_2 - t_1}, \text{ (g day}^{-1}\text{)} \quad (1)$$

$$\text{Relative growth rate (RGR)} = \frac{L_n DM_2 - L_n DM_1}{t_2 - t_1}, \text{ (g g}^{-1}\text{ day}^{-1}\text{)} \quad (2)$$

$$\text{Duration of leaf area (DLA)} = \frac{(LA_1 + LA_2)}{2} \, x \, (t_2 - t_1), \text{ (cm}^2\text{ day}^{-1}\text{)} \quad (3)$$

$$\text{Net assimilation rate (AR)} = \frac{DM_2 DM_1}{LA_2 LA_1} \, x \, \frac{L_n LA_2 - L_n LA_1}{(t_2 - t_1)}, \text{ (g cm}^{-2}\text{ day}^{-1}\text{)} \quad (4)$$

Location:

t_1 = 40 DAP;

t_2 = 124 DAP;
DM_1 = Plant Dry Mass at 40 DAP;
DM_2 = Plant Dry Mass at 124 DAP;
LA_1 = Leaf Area at 40 DAP;
LA_2 = Leaf Area at 124 DAP;
$L_n LA_1$ = Napierian logarithm of leaf area at time t_1;
$L_n LA_2$ = Napierian logarithm of leaf area at time t_2;

The dry mass from different parts of the plants and leaf area from the second evaluation (124 DAP) were used to evaluate the following:

$$\text{Biomass allocation of the leaves} = \frac{\text{Leaf DM}}{\text{Plant DM}} \times 100\ (\%) \quad (5)$$

$$\text{Biomass allocation of the stalks} = \frac{stalk\ DM}{Plant\ DM}\ x\ 100\ (\%) \quad (6)$$

$$\text{Biomass allocation of the roots} = \frac{Root\ DM}{Plant\ DM}\ x\ 100\ (\%) \quad (7)$$

$$\text{Root/A.P.} = \frac{Root\ DM}{Aerial\ part\ DM} \quad (8)$$

$$\text{Leaf area ratio (LAR)} = \frac{LA}{Plant\ DM},\ (cm^2\ g^{-1}) \quad (9)$$

$$\text{Specific leaf area (SLA)} = \frac{LA}{Leaf\ DM},\ (cm^2\ g^{-1}) \quad (10)$$

At 120 DAP, after inducing drought stress for 3 days, with visible leaf wilting, physiological analyzes were performed only on plants treated with the commercial products to see if they would induce drought stress tolerance. Whilst the SPAD index was quantified in all treatments.

The photochemical efficiency was measured on the middle third of the top visible dewlap (TVD) leaves of each plant at 120 DAP. The maximum quantum yield (Fv/Fm) was measured at 4:30am and at noon, with a portable chlorophyll fluorometer, model OS-1FL (ADC BioScientific, Ltd., Hoddesdon, England), with saturating modulated light pulse of 1s duration, according to the method described by Maxwell and Johnson (2000). The Fv/Fm was measured after dark conditioning, with plastic tweezers for 20 minutes. The PSII effective quantum yield (Φ_{PSII}) was measured between 11:00am and noon on the same leaves taken to measure Fv/Fm, performing two readings per plant, according to Schreiber et al. (1995).

The chlorophyll content on the sugarcane leaves was estimated *in vivo* via SPAD index with a portable chlorophyll meter, model SPAD-502 (Minolta Co, Ltd., Osaka, Japan), at 122 DAP. Eight random readings were performed on the middle third of the TVD leaf of each plant.

Gas exchange quantification was performed with a portable photosynthesis system (IRGA), model LCi (ADC BioScientific, Ltd., Hoddesdon, England) in the middle third of the TVD leaves between 10:00am and noon at 120 DAP, with one reading per plant. All measurements were made at ambient CO_2 concentration and humidity. Short term fluctuations of CO_2 and humidity were eliminated by sucking atmospheric air into a 20 L plastic chamber prior to the equipment measurements being taken. The CO_2 concentration in the cuvette was stable close to 365 µL L^{-1}. The photosynthetic photon flux density in the IRGA cuvette was fixed at 1000 µmol m^{-2} s^{-1} with an artificial light source. The evaluated parameters were: photosynthesis (A), stomatal conductance (gs), transpiration (E), internal CO_2 concentration (Ci) and instantaneous carboxylation efficiency (A/Ci).

The results were submitted to variance analysis at 5% and 1% probability by t-test with means and compared by Duncan Test at5% probability.

RESULTS

Biomass production of plants treated with IBA and Stimulate® was approximately 25% higher than the Control treated plants (Table 2). This may have been a consequence of the root system growth, which was 83% (IBA) and 80% (Stimulate®) higher compared to the Control treated ones. This larger plants' root system was also made evident on the biomass allocation of the roots, about 43% (IBA) and 40% (Stimulate®) higher than the Control treated plants (Table 2). The biomass allocation of the leaves was higher for B+Zn, Tryptophan, Ubyfol® and Control treatments and lower in IBA and Stimulate® treatments (Table 2). Meanwhile, leaf area (LA) was 16% higher in plants treated with Stimulate® compared to the ones receiving Control treatment (Table 2). Plants receiving IBA and Stimulate® treatment had the lowest leaf area ratio (Table 2).

Net assimilation rate was higher for plants treated with IBA (21%) and Stimulate® (9%) and lower for the ones under Ubyfol® treatment (-8%) compared to the Control treated ones (Table 2). Plants treated with IBA and Stimulate® showed relative growth rate about 27% higher than the Control treated ones (Table 2). Plants treated with B+Zn and Tryptophan had the lowest values for relative growth rate, about -6.25 and -9.37%, respectively, compared to Control treated plants.

Tryptophan application was the only one not to show an increase on the sugarcane leaf area duration compared to the Control treated ones. The dry mass ratio of root/shoot was significantly higher in plants treated with IBA, Tryptophan, Ubyfol® and Stimulate® compared to Control and B+Zn treatments. The leaf and stalk dry mass, stalk percentage, plant height, stalk diameter, number of leaves, number of tillers and specific leaf area (Table 2) did not differ between treatments. The Stimulate® application increased the sugarcane SPAD index by 6% compared to the Control treatement (Figure 2). The B+Zn, Tryptopnan and Ubyfol® application appear to stimulate the chlorophyll production, however, they have not differed significantly from Control treated ones.

Drought stress caused a Fv/Fm reduction on plants receiving B+Zn, Ubyfol® and Control treatment compared to the hydrated plants (Figure 3A). The plants treated with IAB and Stimulate® had less dynamic photoinhibition, both irrigated and under drought stress plants (Figure 3B). On well hydrated plants, all treatments improved the Φ_{PSII}, and had strong reduction in Φ_{PSII} when under drought condition; however, this reduction was less on Ubyfol® and Stimulate® treatments (Figure 3C).

The Ubyfol® and Stimulate® application increased the stomatal conductance in hydrated plants (Figure 4A). This reflected on the transpiration and photosynthesis of these plants (Figure 4B-C). On drought stressed plants, only Stimulate® treated plants maintained higher stomatal conductance, photosynthesis and transpiration compared to untreated plants.

Table 2. Leaf dry mass (Leaf DM), stalk dry mass (Stalk DM), root dry matter (Roots DM), biomass allocation of the leaf (leaf weight ratio, LWR), biomass allocation of the stalk (stalk weight ratio, SWR), biomass allocation of the root system (root weight ratio, RWR), leaf area (LA), plant height, stalk diameter, number of leaves, number of tillers, net assimilation rate (AR), absolute growth rate (AGR), relative growth rate (RGR), duration of leaf area (DLA), leaf area ratio (LAR), Specific leaf area (SLA) and root to shoot ratio (Root/shoot) of sugarcane at 124 DAP under the influence of root-promoting substances. Averages in the same row followed by the same letter do not differ according to Duncan's Test (P<0.05).

Parameter	Treatments					
	Control	**IBA**	**B + Zn**	**Tryptophan**	**Ubyfol®**	**Stimulate®**
1. Leaf DM (g plant^{-1})	21.82^{A}	22.13^{A}	22.05^{A}	19.90^{A}	22.52^{A}	22.27^{A}
2. Stalk DM (g plant^{-1})	61.14^{A}	68.31^{A}	65.62^{A}	56.20^{A}	55.26^{A}	69.36^{A}
3. Root DM (g plant^{-1})	22.60^{B}	41.43^{A}	22.14^{B}	26.87^{B}	32.18^{AB}	40.72^{A}
4. Plant DM (g plant^{-1})	105.57^{B}	131.87^{A}	109.82^{B}	102.98^{B}	109.97^{B}	132.36^{A}
5. LWR (%)	21.16^{A}	17.45^{B}	20.99^{A}	19.53^{AB}	20.90^{A}	17.06^{B}
6. SWR (%)	56.72^{A}	50.93^{A}	57.51^{A}	53.05^{A}	49.53^{A}	51.86^{A}
7. RWR (%)	22.11^{B}	31.60^{A}	21.48^{B}	27.40^{AB}	29.55^{A}	31.06^{A}
8. LA (cm^{2} plot^{-1})	1834.63^{B}	1926.17^{AB}	1924.88^{AB}	1850.48^{B}	2070.07^{AB}	2128.02^{A}
9. Plant height (cm)	78.15^{A}	78.28^{A}	83.93^{A}	82.62^{A}	79.59^{A}	81.21^{A}
10. Stalk diam. (mm)	16.15^{A}	16.20^{A}	16.04^{A}	19.05^{A}	16.36^{A}	17.11^{A}
11. Number of leaves	7.81^{A}	7.62^{A}	7.93^{A}	7.56^{A}	7.68^{A}	7.37^{A}
12. Number of tillers	2.31^{A}	2.37^{A}	2.56^{A}	2.56^{A}	2.50^{A}	2.50^{A}
13. AR (g cm^{-2} dia^{-1})	0.53^{BC}	0.64^{A}	0.53^{BC}	0.51^{BC}	0.49^{C}	0.58^{AB}
14. AGR (g dia^{-1})	1.17^{B}	1.49^{A}	1.20^{B}	1.12^{B}	1.23^{B}	1.50^{A}
15. RGR (g g^{-1} dia^{-1})	0.032^{CD}	0.035^{AB}	0.030^{D}	0.029^{D}	0.033^{BC}	0.036^{A}
16. DLA (cm^{2} dia^{-1})	94673^{C}	99124^{AB}	101179^{AB}	97026^{BC}	105745^{AB}	108389^{A}
17. LAR (cm^{2} g^{-1})	17.88^{A}	15.25^{C}	18.45^{AB}	18.44^{AB}	19.29^{A}	16.39^{BC}
18. SLA (cm^{2} g^{-1})	84.51^{A}	92.10^{A}	89.76^{A}	127.52^{A}	92.72^{A}	103.36^{A}
19. Root/shoot	0.29^{B}	0.58^{A}	0.28^{B}	0.41^{AB}	0.46^{AB}	0.47^{AB}

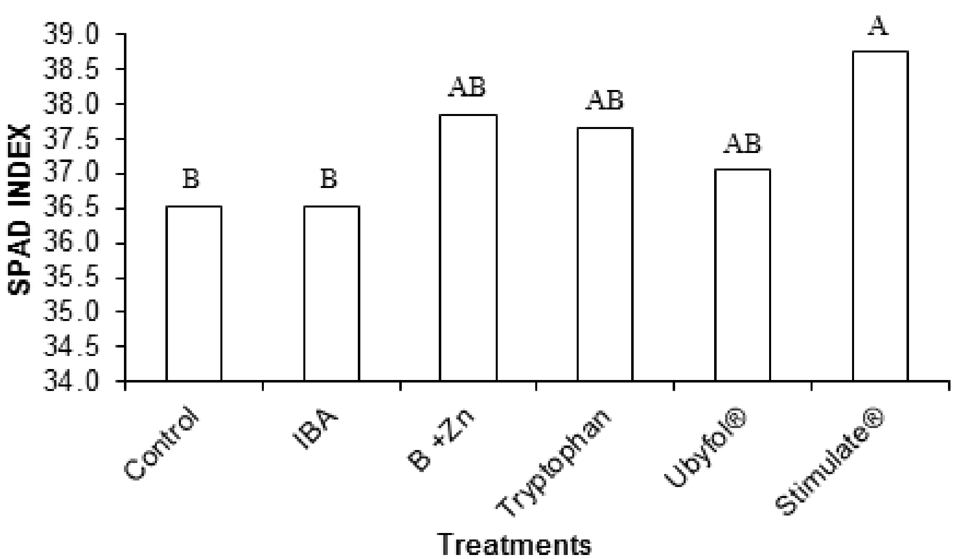

Figure 2. SPAD index of sugarcane at 124 DAP with the application of bio-stimulants. Averages followed by the same letter do not differ according to Duncan's test (P<0.05).

DISCUSSION

Plants treated with IBA and Stimulate® had about 43% and 40.5% higher biomass allocation of their roots compared to Control treated plants, respectively (Table 2). Auxin induces the formation of root hairs, as well as

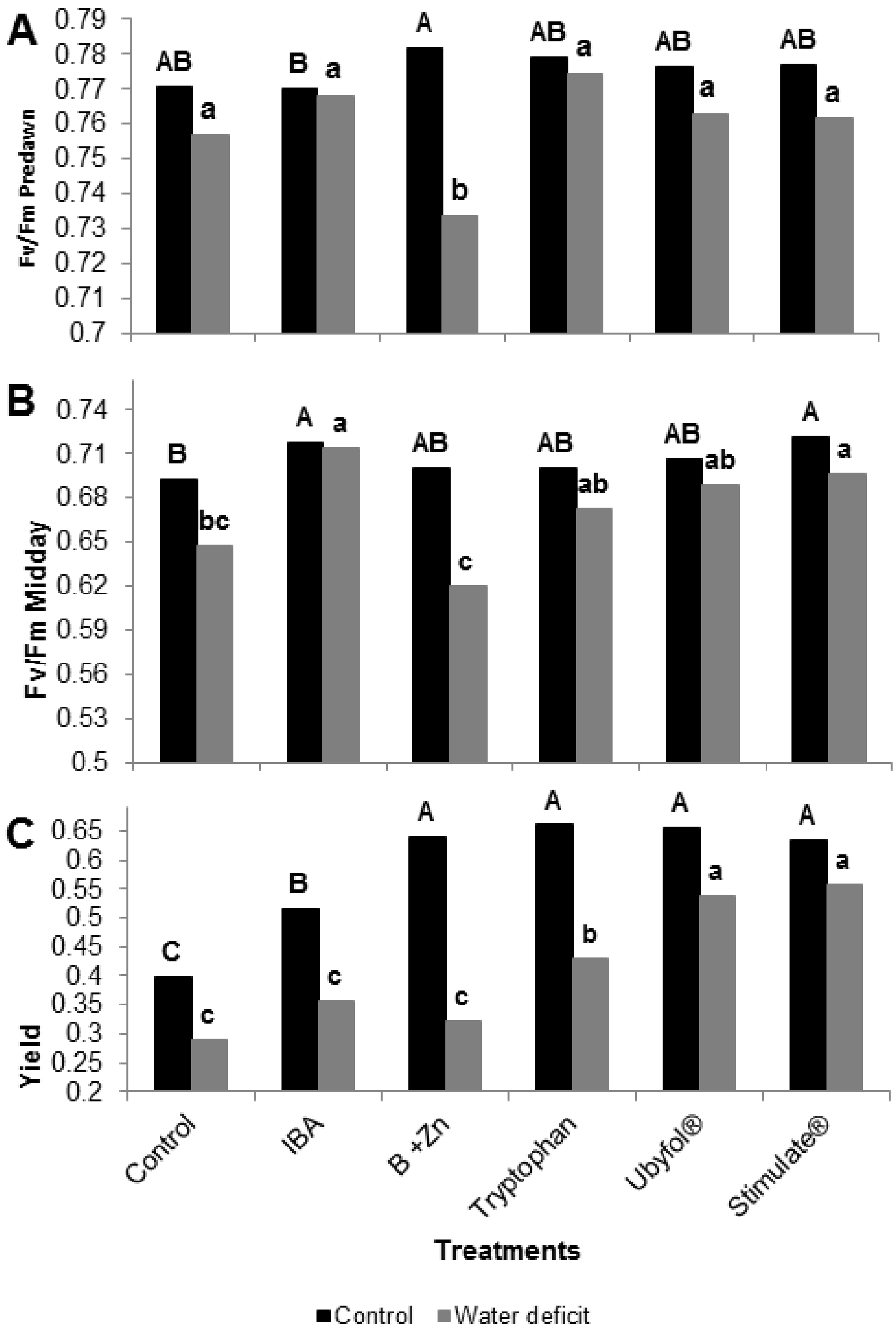

Figure 3. Maximum quantum yield of photosystem II (Fv/Fm) at predawn (A) and at midday (B) and, Effective photosystem II yield (Φ_{PSII}) at midday (C) on sugarcane leaves at 120 DAP with the application of bio-stimulants and reinforcers. The average between treatments followed by uppercase and lowercase letters in the same color columns do not differ according to Duncan's test (P < 0-05). The averages within each treatment superscript ** and * differ without stress and stressed at 1% and 5% by t-test, respectively.

lateral root formation (Péret et al., 2011). This increases the root system and probably the water and nutrient adsorption, favoring the absolute and relative growth rate, which was also observed by Verri et al. (1983) on IBA treated sugarcane, and by Dantas et al. (2012) on Stimulate® treated tamarind. Thus, when an auxin biosynthesis inhibitor was applied to tomato seedlings, the root relative growth rate was inhibited (Higashide et

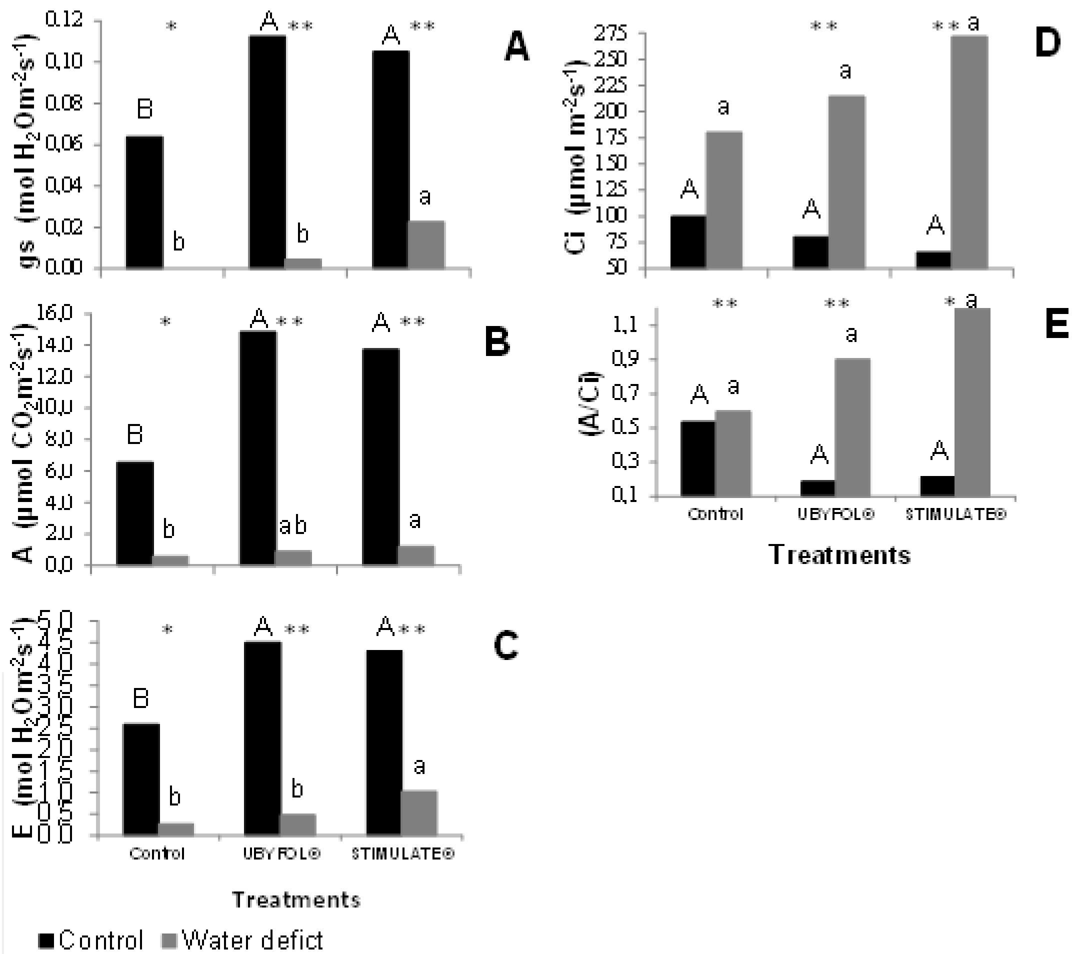

Figure 4. Stomatal conductance, gs (A), photosynthesis, A (B), transpiration, E (C), intercellular CO_2 concentration, Ci (D) and instantaneous carboxylation efficiency, A/Ci (E) of sugarcane at 120 DAP with the application of bio-stimulants and root-promoting substances. The averages followed by the same uppercase and lowercase letters in columns of the same color do not differ according to Duncan's test (P < 0-05). The averages within each treatment superscript ** and * differ from controlled and stressed at 1% and 5% by t-test, respectively.

al., 2014).

All products used in this work, with the exception of tryptophan, have increased the sugarcane leaf area duration, conveying the time that the photosynthetic leaf area is effectively active, that is, the leaf area magnitude and persistence (Coombs et al., 2014; Costa et al., 2000), potentially enabling greater sugarcane productivity. Similarly, in Sugar beet, the yield was directly affected by the leaf area index and leaf area duration (Cerkal et al., 2007). According to Delgado (1995), the yield potential of a given rice cultivar may be related to the leaf area duration. It was also a strong determinant of biomass yield across genotypes of poplar (Verlindenet al., 2015). The increase in leaf area ratio is related to the improvement of the plant nutritional status, as a result of increased allocation of assimilates for leaf development, resulting in higher leaf weight values and/or leaf area growth (Porter, 1989). Moreover, as the plant grows, there may be a reduction in leaf area ratio due to an interference increase of upper leaves on the lower leaves by self-shading (Benincasa, 1988). This should have been the case in this work (Table 2), since the plants with greater LA showed less leaf area ratio.

The biomass allocation of the leaf and stalk, plant height, stalk diameter, number of leaves, number of tillers and specific leaf area (Table 2) have not differed between treatments. This may be due to the fact that measurements were taken at 124 DAP, when the sugarcane had not yet reached its peak growth and carbon accumulation, and it could still be under the influence of plant cuttings reserve used for propagation (Santos et al., 2009). Meanwhile, the following parameters: leaf area ratio, root to shoot ratio (root/shoot), leaf area, root mass, plant mass and biomass allocation of the root system (root %)

were good variables to detect changes in the initial growth of sugarcane.

According to Davies (2004), auxins and cytokinins may delay leaf senescence. This may be the reason why treated plants with Stimulate® had higher SPAD readings, since its formulation contains cytokinin and gibberellin.

The PSII maximum quantum yield (Fv/Fm) at predawn indicates chronic photoinhibition when presenting values below 0.7 (Dias and Marenco, 2007). In our experiment, even on plants subjected to stress, Fv/Fm below 0.7 was not observed at predawn, showing that the drought stress was moderate and allowing overnight recovery of the photosynthetic apparatus. According to Bolhar-Nordenkampf et al. (1989), Fv/Fm between 0.75 and 0.85 are characteristic of plants under optimal growth conditions.

A decrease in Fv/Fm throughout the day is an accurate indicator of photoinhibitory damage, when the plants are subject to environmental stresses, including cold and dry (Björkman and Powles, 1984). The plants treated with IBA, Ubyfol® and Stimulate® presented minor damage to the photosynthetic apparatus, that is, less energy loss by photoinhibition along the day, and consequently may have greater conversion of energy into biomass. Meanwhile, the other plants showed a decrease in Fv/Fm, similar to those found by Silva et al. (2007) and Molinari et al. (2007) in sugarcane under drought stress and by Heckathornet al. (1997) in a greenhouse experiment with C_4 prairie grasses under drought stress conditions.

The application of biostimulants reduced the photo-inhibition throughout the day and increased the photosystem II yield (ΦPSII) compared to the Control treated plants when the water conditions where adequate. In plants under stress, the ΦPSII reduction was less intense in plants under Ubyfol® and Stimulate® treatments (Figure 3C). Plants under these treatments also showed high root/shoot ratio, allowing a better use of soil moisture. Silva (2010) found ΦPSII values of 0.65 in sugarcane plants subjected to moderate drought stress, and 0.62 when subjected to severe drought stress. In this work, lower values were observed when subjected to drought stress conditions.

The application of Ubyfol® and Stimulate® biostimulants improved the photochemical efficiency and significantly increased the leaves gas exchange (Figure 4), indicating a more intense photosynthetic activity. However, under drought stress conditions, the stomatal closure to minimize water loss through transpiration can trigger the reduction of CO_2 diffusion to the substomatal cavity, resulting in smaller photosynthesis activity (Prado et al., 2001). In our work, even in these conditions, plants treated with Stimulate® showed the highest stomatal conductance, transpiration and photosynthesis rates amongst treatments.

The highest stomatal conductance and transpiration rates on Stimulate® treatment under water deficit conditions verified in this experiment, possibly occurred due to these plants greater roots dry mass ratio compared to the other ones, allowing an increase in water and nutrients absorption from the soil. According to Chaves (1991), the maintenance of stomatal opening in drought stress conditions is due to the ability of some plants to extract water from the soil fast enough to compensate for the losses in carbon assimilation. This adaptation can be achieved by plants with deep root systems. It was also found that the Ubyfol® and Stimulate® treatments had the highest rates of photosynthesis; however the Stimulate® treatment presented the highest carbon accumulations with the highest total plant dry mass.

Conclusions

The application of IBA and Stimulate® treatments enables higher growth rates and biomass accumulation in the initial phase of the sugarcane vegetative growth. When compared to Control treated plants, the application of Ubyfol® and Stimulate® treatments enables greater gas exchange in the absence of drought stress and increases the photosystem II yield even when plants are under drought stress. In plants under moderate stress, Stimulate® treatment application allows higher stomatal conductance, transpiration and photosynthesis rates.

Conflict of Interests

The authors have not declared any conflict of interest.

REFERENCES

Albrecht LP, Braccini AL (2009). Aplicação de biorregulador na produtividade do algodoeiro e qualidade de fibra. Scientia Agrari. 10(3):191-198.

Albrecht LP, Braccini AL, Scapim CA, Ávila MR, Albrecht AJP, Ricci TT (2011). Manejo de biorregulador nos componentes de produção e desempenho das plantas de soja. Biosci. J. 27(6):865-876.

Artlip T, Wisniewski M (2002). Induction of proteins in response to biotic and abiotic stresses. In: M. Pessarakli (ed) handbook of Plant Crop Physiol. pp. 657-680.

Ayele N, Dengia A, Getaneh A, Mengistu L, Dilnesaw Z (2014). Effects of bioactivators on yield and yield components of sugarcane at wonji-shoa sugar estate. Int.J.Advanced Res.Biol. Sci. 1:138-143.

Benincasa MMP (1988). Análise de crescimento de plantas: noções básicas. Botucatu: FUNEP.

Bertolin DC, Sá ME, Arf O, Junior EF, Colombo AS, Carvalho FLBM (2010). Aumento da produtividade de soja com a aplicação de bioestimulantes. Bragantia 69(2):339-347.

Björkman O, Powles SB (1984). Inhibition of photosynthetic reactions under water stress: interaction with light level. Planta 161:490-504.

Bolhar-nordenkampf HR, Long SP, Baker NR, Oquist G, Shreiber U, Lechner EG (1989). Chlorophyll fluorescence as a probe of the photosynthetic competence of leaves in the field: a review of current instrumentation. Functional Ecol. 3:497-514.

Cairo P, Oliveira L, Mesquita A (2008). Análise de crescimento de plantas. Vitória da Conquista: Edições UESB.

Cakmak I, Marschner H, Bangerth F (1989). Effect of zinc nutritional status on growth, protein metabolism and levels of indole-3-acetic acid and other photo hormones in bean (*phasseolus vulgaris*). J. Exp. Bot. 40:405-412.

Calvo P, Nelson L, Kloepper JW (2014). Agricultural uses of plant

biostimulants. Plant and Soil 383:3-41.
Castro PR (2006). Agroquímicos de controle hormonal na agricultura tropical. Boletim, 32, Série Produtor Rural, uso/esalq/dibd, Piracicaba.
Cerkal R, Dvorak J, Verjrazka K, Kamler J (2007). The effect of leaf area reduction on the yield and quality of sugar beet (beta vulgaris l. var. altissima döll). Acta Univ. Agric. Silvic. Mendel. Brun. 55(5):37-44.
Chaves MM (1991) Effects of water deficits on carbon assimilation. J.Exp. Bot. 42:1-16.
Choi EY, Kolesik P, Mcneill A, Collins H, Zhang Q, Huynh BL, Graham R, Stangoulis J (2007). The mechanism of boron tolerance for maintenance of root growth in barley (*Hordeum vulgare* L.). Plant, Cell Environ. 30(8):984-993.
Coombs J, Hall DO, Long SP, Scurlock JMO (eds.) (2014). Techniques in bioproductivity and photosynthesis: pergamon international library of science, technology, engineering and social studies. Elsevier.
Costa EDC, Santos AD, Zimmermann FJP (2000). Crescimento da cultura principal e da soca de genótipos de arroz irrigado por inundação. Pesquisa Agropecuária Bras., Bras. 35:1949-1958.
Dantas ACVL, Queiroz JMO, Vieira EL, Almeida VO (2012). Effect of gibberellic acid and the biostimulant stimulate® on the initial growth of tamarind. Rev. Bras. Frutic. 34(1):8-14.
Davies PJ (ed) (2004). Plant hormones: biosynthesis, signal transduction, action!. Springer Science & Business Media.
Delgado AD (1995). Analisis de crecimiento de la biomasa y el área foliar en la variedad de arroz: Oryzica Yucu-9. Arroz (Colombia) 399:41-48.
Dias DP, Marenco RA (2007). Fotossíntese e fotoinibição em mogno e acariquara em função da luminosidade e temperatura foliar. Pesquisa Agropecuária Brasileira 42:305-311.
Fachinello JC, Kersten E (1996). Fitorreguladores in: Nachtigal JC, Fachinello JC. Fruticultura-fundamentos e práticas. Pelotas: editora e grafica UFPEL.
Ferreira júnior RA, Souza JL, Lyra GB, Teodoro I, Santos MA, Porfirio ACS (2012). Crescimento e fotossíntese de cana-de-açúcar em função de variáveis biométricas e meteorológicas. Res. Bras.Eng. Agríc. Ambient. 16(11):1229-1236.
Garcia RA, Gazola E, Merlin A, Bôas RLV, Crusciol CAC (2009). Crescimento aéreo e radicular de arroz de terras altas em função da adubação fosfatada e bioestimulante/shoot and root growth of upland rice as affected by phosphorus fertilization and biostimulant. Bioscience J. 25: 65-72.
Goldbach HE, Yu Q, Wingender R, Schulz M, Wimmer M, Findeklee P, Baluska F (2001). Rapid response reactions of roots to boron deprivation. J.Plant Nutrition Soil Sci.164:173-181.
Haggquist ML, Strid I, Widell KO, Lijenberg C (1998). Identification of tryptophan in leachate oat hulls (avena sativa) as mediator of root growth regulation. Physiol. Plant. 72:423-427.
Heckathorn SA, Delucia EH, Zielinski RE (1997). The contribution of drought-related decreases in foliar nitrogen concentration to decreases in photosynthetic capacity during and after drought in prairie grasses. Physiol.Plant. 101:173-182.
Higashide T, Narukawa M, Shimada Y, Soeno K (2014). Suppression of elongation and growth of tomato seedlings by auxin biosynthesis inhibitors and modeling of the growth and environmental response. Sci. Reports 4:4556.
Kramer PJ (1983). Water relations of plants. New York: academic press.
Liu D, Jiang W, Zhang L, Li L (2000). Effects of boron ions on root growth and cell division of broadbean (*Vicia faba* L.). Israel J. Plant Sci. 48(1):47-51.
Maxwell K, Johnson GN (2000). Chlorophyll fluorescence—a practical guide. J. Experimental Bot. 51:659-668.
Molinari HBC, Marur CJ, Daros E, Campos MKF, Carvalho JFRP, Filho JCB, Pereira LFP, Vieira LGE (2007). Evaluation of the stress-inducible production of proline in transgenic sugarcane (*Saccharum* spp.): osmotic adjustment, chlorophyll fluorescence and oxidative stress. Physiol. Plant 130(2):218-229.
Péret B, Clément M, Nussaume L, Desnos T (2011). Root developmental adaptation to phosphate starvation: better safe than sorry. Trends Plant Sci. 16(8):442-450.
Porter NG (1989). Composition and yield of commercial essential oils from parsley. 1: herb oil and crop development. Flavour Fragrance J. 4:207-219.
Prado CHBA, Passos EEM, de Moraes JAPV (2001). Photosynthesis and water relations of six tall genotypes of cocos nucifera in wet and dry seasons. S. Afr. J. Bot. 67: 169-176.
Santos VM, Melo AV, Siebeneichler SC, Cardoso DP, Benício LPF, Varanda MAF (2013). Physiological indices of seedlings of maize (zea mays l.) under the action of biostimulants. J. Biotechnol. 4(3):232-239.
Santos VR, Moura filho G, Albuquerque AW, Costa PV, Santos CG, Santos ACI (2009). Crescimento e produtividade agrícola de cana-de-açúcar em diferentes fontes de fósforo. Res. Bras.Eng. Agríc.Ambient. 13(4):389-396.
Schreiber U, Hormann H, Neubauer C, Klughammer C (1995). Assessment of photosystem ii photochemical quantum yield by chlorophyll fluorescence quenching analysis. Func. Plant Biol. 22(2):209-220.
Serciloto CM (2002) Bioativadores de plantas. Revista Cultivar HF 13:20-21.
Silva MA (2010). Biorreguladores: nova tecnologia para maior produtividade e longevidade do canavial. Pesquisa e Tecnologia 7:1-10.
Silva MDA, Cato SC, Costa AGF (2010). Productivity and technological quality of sugarcane ratoon subject to the application of plant growth regulator and liquid fertilizers. Ciência Rural 40:774-780.
Silva MDA, Jifon JL, Silva JAG, Sharma V (2007). Use of physiological parameters as fast tools to screen for drought tolerance in sugarcane. Brazilian J. Plant Physiol. 19(3):193-201.
Sinclair TR, Gilbert RA, Perdomo RE, Brilhar JM, Powell L, Montes G (2004). Sugarcane leaf area development under field conditions in Florida, USA. Field Crops Res. 88:171-178.
Verlinden MS, Broeckx LS, Ceulemans R (2015). First vs. second rotation of a poplar short rotation coppice: above-ground biomass productivity and shoot dynamics. Biomass Bioenergy 73:174-185.
Verri AR, Pitelli RA, Casagrande AAA, Castro PRC (1983). Reguladores vegetais no enraizamento e desenvolvimento de gemas de cana-de-açúcar tratadas termicamente. Anais da Escola Superior de Agricultura Luiz de Queiroz 40:381-394.

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Phenology, yield and fruit quality of four persimmon (*Diospyros kaki* L.) cultivars in São Paulo's Midwest countryside, Brazil

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The aim of this study is to evaluate the phenology, yield and fruit physicochemical characteristics of four persimmon cultivars (*Diospyros kaki* L.) in São Paulo's Midwest countryside, Brazil. The persimmon cultivars studied were 'Pomelo', 'Rama Forte', 'Fuyu' and 'Rubi'. The main phenological phases of persimmons trees were evaluated. Despite significant differences between cultivars in the early and intermediate stages of the plants development such as branch development, full blossom and fruiting's onset, the time required between the fruit's pruning and harvesting was similar among the cultivars. It could be observed that only 'Pomelo' persimmon trees presented male flowers. However on 'Rubi', 'Fuyu' and 'Rama Forte' persimmons trees were found the largest number of female flowers, fruits fixation index and number of fruits per branch. Nevertheless, there were no differences among the cultivars regarding productivity, which could be due to the persimmon fruits physical characteristics. The fruits' diameter growth behavior was evaluated and it was observed that all cases were defined as double sigmoidal, defined by three single phases. Regarding the chemical characteristics, there were no differences among the cultivars' pH and soluble solids content; however, in general, the 'Pomelo' persimmon fruit presented less titratable acidity and a higher maturation index rating.

Key words: Fruit growth, fruit set, flowering, double sigmoid, maturity.

INTRODUCTION

Persimmon cropping (*Diospyrus kaki* L.) has grown in importance over the last years in Brazil, both in terms of acreage and consequently, production's increase, which has raised the amount of fruits offered to the domestic market. Thus, for this reason, growers have been encouraged to export part of their harvest (Silva et al.,

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2011)

Brazil is the fourth highest producer in the world's persimmon production ranking, whilst China is the biggest one, followed by Japan and South Korea. Brazil's South and Southeast regions are the largest producers, led by the state of São Paulo (Silva et al., 2011). In this state particularly, the main producer towns in 2015, were Mogi das Cruzes, Campinas and Sorocaba with 49.9; 19.5 and 17.8 thousand tons of fruit, respectively, while Botucatu, in São Paulo's Midwest countryside, produced only 208 tons in the same year (IEA, 2016). The main varieties produced and sold within Brazilian domestic market are, primarily 'Rama Forte', 'Giombo' and 'Fuyu' fruits, despite pomological characteristics and other varieties' production, such as 'Pomelo' and 'Fuyuhana' (Pereira and Kavati, 2011). What could be observed was that even though the culture has established itself and several of its centers of production, as well as variety with high production and commercial potential, it is possible to notice that technological evolution for persimmon's culture and plantation remains stagnant. Probably, the little commercial interest the culture kept for a long time and the easy production, due to the roughness and high yield of the crops, have been some of the factors responsible for slowing down studies that seek new culture technologies developed for the crop (Pereira and Kavati, 2011).

In order to meet quality demanded standards from the consumer market, there is a need to expand the research field for knowledge regarding persimmon cropping, including aspects ranging from nutrition, irrigation and plants' canopy handling to before and after harvest studies (Biasi et al., 2007; Souza et al., 2011; Vieira et al., 2016), considering that these factors might be affected by growing's location and chosen crop. The fruit farm, for instance, when led according to different growth stages, allows strategies and decisions to be defined beforehand, which contributes to improving the crops' efficiency and yield (Corsato et al., 2005).

Therefore, studies on phenological persimmon characteristics are also essential, since they allow the creation of growth models describing and planning in advance the crop's growth in each region. Besides, it is also essential to evaluate physical and chemical qualities of the fruit, whereas persimmon is consumed mainly in its natural form and the sugar and acid contents as well as their (sugar/acid) contrast relationship contribute greatly to the fruit's sensorial attributes (Veberic et al., 2010).

Considering these contexts, the aim of this study was to evaluate the phenology, yield and fruit physicochemical characteristics of four persimmon cultivars in São Paulo's Midwest countryside, Brazil.

MATERIALS AND METHODS

Experimental site, plants' growing condition and handling

This study was carried out inside persimmon fruit orchard located in Botucatu, in the state of São Paulo, Brazil's southeast (22° 55' 55" S, 48° 26' 22" W, 810 m above the sea), from July 2013 to January 2014. According to the Köppen classification, the climate is type *Cwa*, that is, a subtropical weather with an average temperature at 20.7°C, and a rainfall yearly average rate of 1359 mm, of which most of the rain season occurs during the summer months (CEPAGRI, 2016). The soil of the area was classified as UDULT according to the Brazilian company Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA, 2006).

The experimental procedures consisted of four persimmon cultivars: 'Pomelo' (IAC 6-22), 'Rama Forte', 'Fuyu' and 'Ruby' (IAC 8-4), all of them grafted on the 'Pomelo' rootstock. The persimmon trees were 4 year-old crops, and they were arranged in 3 x 3 m seeding spots inside an orchard without irrigation system. The annual winter pruning was performed July 13th 2013, when the trees were in their dormancy period and before early budding. During the pruning, dry, diseased, broken and weak darkened branches were removed.

Measurements

Phenological stages of persimmon plants

After budding starts, according to García-Carbonell et al. (2002), with slight differences, were assessed the following phenological stages: branch development and closed flower buds– visible but still jointed sepals; bud opening start– the parting of the sepals; full bloom– when 50% of the flowers reach anthesis; the onset of fruiting– when most petals fall down; the start of the physiologic fruit drop; fruits known as "chumbinho"– when the fruits reach about 20% of their normal size; these fruits start losing their green color; the maturation and harvesting. The assessments were performed weekly and the phenological stages lengths were expressed as days after pruning (DAP).

Flowering, fruit's set and growth development

In the beginning of anthesis, the number of female (FF) and male flowers in 10 productive established branches were determined in each branch, in the early stages of maturation, with all this data, the number of fixed fruits (NFF) were counted to determine fixation index fruits (FIF), using the formula proposed by Corrêa et al. (2002): FIF = [(NFF/FF) 100]. Afterwards, 10 fruits were selected per experimental trials and measured weekly with a digital caliper. The transverse diameter of the fruits produced a growth curve.

Yield

The yield per plant (kg) and productivity (t ha^{-1}) were estimated based on the number of fruits per tree and their mass. Harvesting was performed when fruits reached their physiological maturation, showing firm pulp.

Physicochemical fruits characteristics

In order to eliminate tannin, the fruits were exposed to volatilized ethyl alcohol for 48 h (contents: 70 ml alcohol to 12 kg fruit). Then, they were kept under environmental condition (17 ± 2°C) until full maturation. After that, a physicochemical analysis of 10 chosen fruits per experimental trial was performed.

The physical characteristics of the persimmon fruits were evaluated by determinations of their mass (g), length (cm) and width (cm). The chemical characteristics were assessed according to determinations of soluble solids content (°Brix), titratable acidity

Table 1. Phenological stages of the different persimmon cultivars grown in São Paulo's Midwest countryside, Brazil. Botucatu-SP, 2014.

Phenological stages (DAP)[1]	Pomelo	Rama Forte	Fuyu	Rubi
Branch development and closed flower bud	41.3 ± 0.5[a]	48.8 ± 6.5[a]	64.5 ± 4.4[b]	58.0 ± 0.0[b]
Start of bud opening	52.0 ± 0.0[a]	62.0 ± 6.7[b]	73.0 ± 5.7[c]	69.5 ± 2.9[bc]
Full bloom	58.0 ± 0.0[a]	68.0 ± 7.1[b]	84.5 ± 5.0[c]	76.5 ± 2.9[bc]
Onset of fruiting	66.0 ± 0.0[a]	74.8 ± 6.7[a]	95.3 ± 5.5[b]	89.0 ± 7.3[b]
Physiologic drop fruits	73.0 ± 0.0[a]	83.5 ± 7.0[ab]	106.3 ± 9.9[c]	96.5 ± 3.7[bc]
Fruits about 20% of its final size	80.0 ± 0.0[a]	94.3 ± 9.6[ab]	113.5 ± 11[c]	103.0 ± 4.1[bc]
Fruits start losing its green color	211.3 ± 0.5[a]	229.0 ± 12[bc]	218.8 ± 5.7[ab]	240.0 ± 0.0[c]
Maturation and harvesting	266.3 ± 3.8[a]	287.3 ± 17[a]	265.8 ± 13[a]	271.5 ± 6.1[a]

Means values ± standard deviation (*n* = 4) followed by different letters in the same row differ significantly (Tukey test, $p < 0.05$). [1]DAP: Days after pruning.

(percent of malic acid), pH and maturation index. In order to obtain these chemical characteristics, the fruits were mashed in a mixer device until they became a homogenized pulp. The titratable acidity was obtained using titration with 0.1 N standardized hydroxide sodium solution with phenolphthalein as the indicator.

Experimental design and statistical analyses

In order to determine the growth curve, a completely randomized design with split plots of four replicates and 10 fruit per repetition was designed. Each plot represented different persimmon cultivars, and subplots were different evaluation times (days after pruning). For other characteristics assessment, a completely randomized design with four handlings and four replicates was set.

All data were analyzed by ANOVA applying the Tukey test, significance of 5% on plots and regression analysis on subplots. The models were chosen based on the coefficient of significance determination ($R^2 \geq 0.70$). For other variables, the data were subjected to ANOVA comparison through the Tukey test at significance of 5%. All analysis was run using the statistical software package SISVAR (Ferreira, 2011). The Pearson's correlation (*r*) analysis was also conducted (with 5 and 1% probability) to investigate the relation within all characteristics evaluated, aided by the statistical software package ASSISTAT (Silva and Azevedo, 2002).

RESULTS AND DISCUSSION

Phenological stages of persimmon plants

'Rubi' and 'Fuyu' persimmon cultivars took more time to reach closed flower buds and branch development stages, it was possible to notice that the petals remained closed until 58 and 64 days after pruning (DAP), respectively, differently from 'Pomelo' and 'Rama Forte' crops, which reached the same stage in 41 and 59 DAP, respectively (Table 1). Although the needed days to observe closed flower buds is similar in all those sorts of crops, the 'Pomelo' cultivar required a shorter time to start closed flower bud opening and then reach its full bloom, this stage was achieved in 52 and 58 DAP, differing from the other sorts of crops.

A study developed in Eldorado do Sul (Rio Grande do Sul, Brazil) with persimmon trees, obtained the same result from 'Pomelo' and 'Rama Forte' crops, which required 50 days to reach full bloom stage, while 'Fuyu' crops needed 62 days (Campos et al., 2015), corroborating the current study results. The precocity of 'Pomelo' and 'Rama Forte' cultivars, and late characteristics of the 'Fuyu' ones, especially in the intermediate phenological stage, seems to be an intrinsic characteristic of these sorts of crops.

The beginning of fruiting in 'Pomelo' and 'Rama Forte' cultivars occurred in 66 and 75 DAP, respectively; with significant differences from the 'Ruby', which reached the same stage on an average of 92 DAP. The 'Ruby' and 'Fuyu' varieties took more days to reach the beginning of physiological fruit drop, which occurred in 96 and 106 DAP, respectively, regarding the "chumbinho" phenological stage, it was observed in 103 and 113 DAP, respectively.

The full bloom period and physiological fruit drop was in average 15 days to 'Pomelo' and 'Rama Forte', and 21 days to 'Fuyu' and 'Rubi' cultivars. The first peak of fruit drop occurred between 20 and 30 days after flowering. This phenological phase occurs when roots and branches of persimmon tree reach their lowest levels of their carbohydrate reserves and simultaneously compete with fruits (George et al., 1997).

The biggest break among phenological phases occurred between the "chumbinho" fruit stage and when fruits start losing their green color, it happened in 105, 131, 135 and 137 days in 'Fuyu', 'Pomelo', 'Rama Forte' and 'Rubi' cultivars, respectively. Due to this small gap observed in 'Fuyu' persimmon tree, the time required to start losing its green color was similar to 'Pomelo', it took 219 and 211 DAP, respectively.

'Rama Forte' and 'Fuyu' cultivars required longer periods to start losing color, around 235 DAP. However, the period in between when fruits started losing their green color and harvesting was only 31 days long for 'Rubi', while 'Rama Forte', 'Pomelo' and 'Fuyu' reached

Table 2. Number of flowers and fruits per branch and fixations index fruits of the different persimmon cultivars grown in São Paulo's Midwest countryside, Brazil (Botucatu-SP, 2014).

Cultivar	Female flowers per branch	Male flowers per branch	Fruits per branch	Fixation index fruits[2] (%)
Pomelo	2.67 ± 0.68[b]	2.44 ± 0.61	1.67 ± 0.47[b]	54.88 ± 17[b]
Rama Forte	3.56 ± 0.14[ab]	no[1]	2.89 ± 0.67[ab]	83.89 ± 13[a]
Fuyu	3.62 ± 0.79[ab]	no	3.00 ± 0.91[a]	69.12 ± 9.9[ab]
Rubi	4.17 ± 0.11[a]	no	2.12 ± 0.14[ab]	64.32 ± 2.2[ab]

Means values ± standard deviation (n = 4) followed by different letters in the same column differ significantly (Tukey test, $p < 0.05$). [1]no: not observed. [2]It was determined using the following formula: Fruits fixation index = [(number of fixed fruits/number of female flowers) 100].

58, 53 and 47 DAP, respectively. Thus, there were no significant differences for all persimmon cultivars on the maturation and harvesting stages, which occurred, in average, in 273 DAP. The same result was obtained by Campos (2014), in Rio das Antas (Rio Grande do Sul, Brazil), where 'Pomelo' and 'Rama Forte' cultivars were more precocious than other varieties, including 'Fuyu' persimmons in the intermediate stages, though all of them reached the final cycle at the same time.

Flowering, fruit's set and growth development

Considering the type of flower, only 'Pomelo' persimmon trees presented male flowers, an average of 2.4 flowers per branch (Table 2). The presence of male flowers in 'Pomelo' persimmon trees was expected. The flower biology of nine persimmon cultivars ('Costata', 'Fuyu', 'Kaoru', 'Mikado', 'Okira', 'Pomelo', 'Rama Forte', 'Regina' and 'Taubaté') was studied, and among them only 'Pomelo' and 'Mikado' presented flowers producing pollen (Campos et al., 2015). A breeding program developed by the Brazilian company Instituto Agronômico de Campinas (IAC, Brazil) aiming to undemanding varieties to cold proved the 'Pomelo' cultivar to be good male flower producers, ensuring self-pollination (Ojima et al., 1985). The possibility of self-pollination could ensure a higher fruit fixation index rating for 'Pomelo' cultivars; however, an average rating of approximately 55% could be noticed.

'Rubi', 'Fuyu' and 'Rama Forte' persimmon trees did not present male flowers, but in these cultivars, the largest number of female flowers were found at an order of 4.17, 3.62 and 3.56 female flowers per branch, respectively. This is an important characteristic, because it is directly correlated with the number of fruits per branch (r = 0.71, p < 0.01) and per plant (r = 0.66, p < 0.01), which will reflect the final yield.

Floral persimmon trees habits are very complex. Depending on the cultivar, the plants may be monoecious, dioecious or hermaphrodites (Campos et al., 2015). Most commercial cultivars are dioecious and bear only female flowers, as observed in this study. When there is no presence of staminate flowers, pollination can happen, persimmon trees may bear parthenocarpic fruits (García-Carbonell et al., 2002), which contributes to poor fruiting (Agustí, 2010). However, it was found that, even though there was no presence of male flowers, 'Rama Forte', 'Fuyu' and 'Ruby' cultivars had higher fruit fixation index ratings and number of fruits per branch. This is due to the presence of 'Pomelo' cultivars acting as a pollination source to the other cultivars. Keeping plants producing male flowers with viable pollen production is an alternative used in Brazil to increase fruiting and thus increasing productivity (Campos et al., 2015).

There was significant interaction between fruit diameter growth among the assessment days (Table 3). During growth stage, 'Pomelo' crops presented fruits larger in diameter; however, there was no difference as compared to 'Rama Forte' and 'Fuyu' cultivar in this study between 142 and 218 DAP. The 76 days period, that composed the interval between 142 and 218 DAP, were defined by low increase on fruit's diameter. The smallest fruit diameter throughout the evaluation period was observed for 'Rubi' cultivar, although, when the fruits reached the final growth stage, 'Rubi' did not present differences as compared to 'Rama Forte' and 'Fuyu' cultivars.

The growth behavior for all persimmon fruits was double sigmoidal (Figure 1), defined by three single phases. Phase I started when the fruits reached the phenological stage "chumbinho" and was characterized by a fast development promoted mainly by cells division. Afterwards, the fruit development gets into sigmoidal growth, which in turn becomes slower (Phase II). The final phase (Phase III) was determined by a period of exponential growth, when color changings and fruit ripening occur. As observed in this study, the same development behavior was noticed in 'Harbiye' persimmon crops, grown in Turkey (Candir et al., 2009).

Yield and physicochemical fruit characteristics

Despite the fact that no differences were observed in yield and productivity among cultivars, with an average of 12.09 kg plant^{-1} and 13.43 t ha^{-1}, respectively (Table 4), 'Rama Forte' produced more fruits (112.2 fruits per plant), approximately 93.4% higher than 'Pomelo' (58 fruits per

Table 3. Growth developments on transverse diameter (mm) of persimmon fruits from different cultivars grown in São Paulo's Midwest countryside, Brazil. Botucatu-SP, 2014.

DAP	Pomelo	Rama Forte	Fuyu	Ruby
101	30.35±1.7^{A}	21.09±6.7^{B}	18.56±2.6^{BC}	14.13±0.6^{C}
108	35.31±1.3^{A}	25.41±6.1^{B}	20.75±2.3^{BC}	17.99±0.7^{C}
115	39.37±2.4^{A}	29.33±5.9^{B}	25.94±1.6^{BC}	20.77±0.7^{C}
126	44.43±1.8^{A}	34.73±5.3^{B}	32.31±2.2^{BC}	27.09±0.7^{C}
134	48.34±1.8^{A}	38.30±4.5^{B}	37.24±3.7^{B}	30.27±0.5^{C}
142	49.33±2.2^{A}	43.69±5.7^{AB}	42.30±4.4^{BC}	36.43±1.5^{C}
149	51.53±2.3^{A}	44.09±5.4^{B}	44.97±4.2^{AB}	37.23±1.4^{C}
157	51.94±2.5^{A}	44.70±4.3^{BC}	47.75±4.6^{AB}	40.33±1.5^{C}
167	54.61±0.9^{A}	48.75±3.8^{A}	48.43±5.2^{A}	40.74±3.8^{B}
183	56.28±1.4^{A}	49.62±4.3^{AB}	51.85±5.3^{AB}	46.52±2.4^{B}
197	57.44±1.0^{A}	51.13±4.7^{AB}	52.93±6.5^{AB}	48.25±2.0^{B}
204	58.39±0.7^{A}	50.43±4.5^{B}	54.17±6.9^{AB}	49.74±2.2^{B}
212	58.91±1.0^{A}	50.84±4.3^{B}	54.20±7.1^{AB}	51.14±2.4^{B}
218	60.55±0.5^{A}	52.14±4.8^{B}	54.94±6.2^{AB}	51.43±2.2^{B}
224	64.30±2.0^{A}	52.70±5.3^{B}	55.90±5.6^{B}	52.80±2.1^{B}
240	68.34±1.4^{A}	55.15±6.6^{B}	58.87±4.0^{B}	55.41±2.0^{B}
244	69.76±0.5^{A}	57.34±8.0^{B}	60.78±4.7^{B}	57.71±1.4^{B}
251	70.49±1.5^{A}	58.32±6.8^{B}	61.90±5.8^{B}	58.88±1.5^{B}
259	71.40±0.8^{A}	60.42±6.4^{B}	61.93±5.5^{B}	59.60±0.8^{B}

Means values ± standard deviation (n = 4) followed by different letters in the same row differ significantly (Tukey test, p < 0.05).

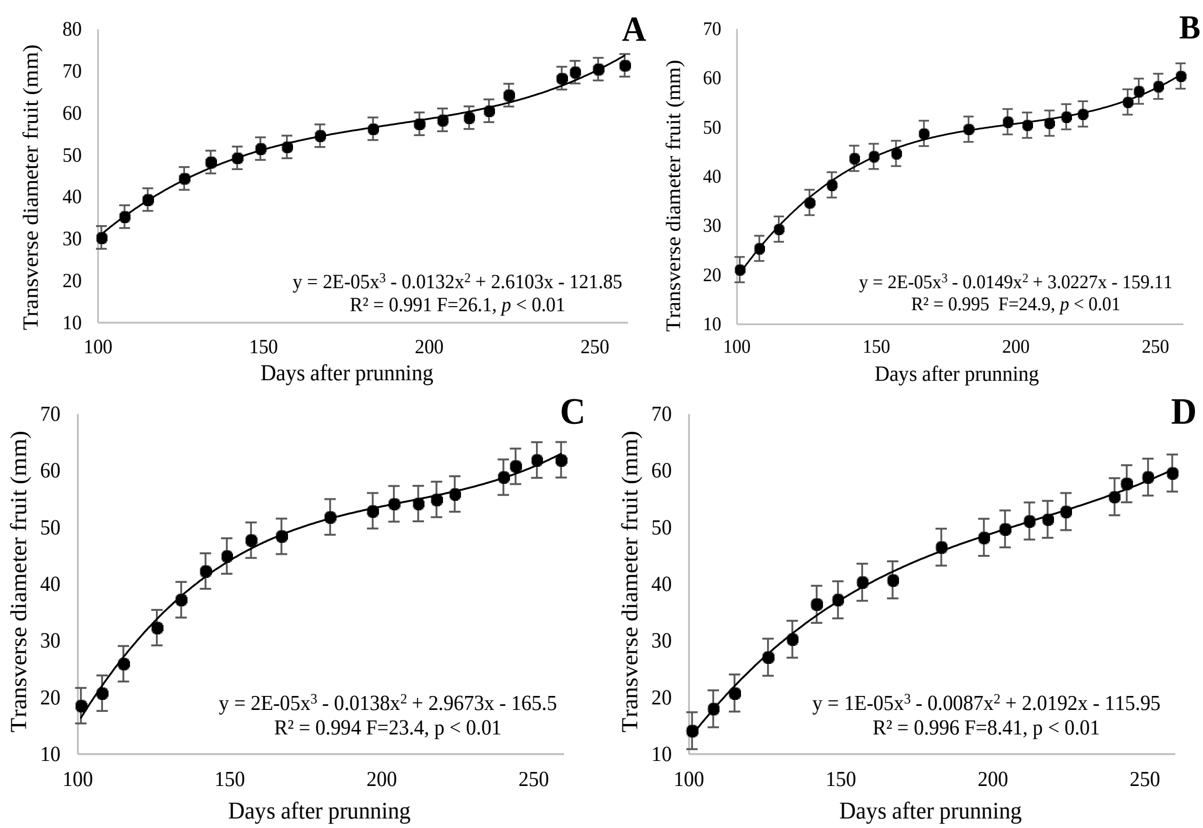

Figure 1. Evolution of persimmon fruits, 'Pomelo' (A), 'Rama Forte' (B), 'Fuyu' (C) and 'Rubi' (D) cultivars grown in São Paulo's Midwest countryside, Brazil, Botucatu-SP, 2014. Deviation lines indicate standard deviation from four replicates, with 10 persimmon fruits each.

Table 4. Yield and physicochemical characteristics of persimmon fruits from different cultivars grown in São Paulo's Midwest countryside, Brazil. Botucatu-SP, 2014.

Cultivar	Yield per plant (kg)	Productivity (t ha^{-1})	Fruits per plant	Fresh fruit mass (g)	Length fruit (mm)
Pomelo	13.93±4.41^{a}	15.48±4.89^{a}	58.00±15.7^{b}	230.9±13.6^{a}	65.50±1.02^{a}
Rama Forte	12.30±4.26^{a}	13.67±4.65^{a}	112.2±20.1^{a}	103.0±29.8^{c}	48.27±8.94^{b}
Fuyu	13.31±2.01^{a}	14.78±2.23^{a}	87.00±10.7^{ab}	150.7±26.1^{b}	62.44±9.18^{a}
Rubi	8.81±2.29^{a}	9.79±2.54^{a}	74.13±7.69^{b}	114.4±18.2^{c}	49.42±5.13^{b}
Cultivar	**Width fruit (mm)**	**pH**	**Soluble solids (°Brix)**	**Titratable acidity (%)**	**Maturation index**
Pomelo	75.22±1.08^{a}	5.36±0.04^{a}	20.23±0.40^{a}	0.11±0.01^{b}	181.8±19^{a}
Rama Forte	60.88±5.64^{c}	5.51±0.11^{a}	19.92±2.72^{a}	0.14±0.03^{a}	147.5±31^{b}
Fuyu	67.57±4.01^{b}	5.33±0.08^{a}	20.96±1.15^{a}	0.13±0.01^{ab}	159.1±16^{ab}
Rubi	61.81±1.79^{c}	5.44±0.12^{a}	20.78±2.06^{a}	0.12±0.01^{ab}	176.1±25^{ab}

Means values ± standard deviation (n = 4) followed by different letters in the same column within the same characteristic differ significantly (Tukey test, $p < 0.05$).

plant) and 51.3% higher than 'Rubi' (74 fruits per plant), proving there is no significant correlation (r = 0.41, p > 0.05) between these characteristics. The productivity of a 12 year-old 'Fuyu' cultivar, grown in Rio das Antas (Santa Catarina, Brazil) was 14.93 t ha^{-1}, with 254 fruits per plant (Souza et al., 2011). Although, their plants were older and with a bigger number of fruits, the yields they obtained were similar to the ones found in this study, considering the same cultivar and the 'Pomelo' and 'Fuyu' ones as well. This shows that these cultivars have a great productive potential, since persimmons trees studied were only 4 years old. According to Pio (2014), the persimmon trees started commercial production at the age of three years old, however they reached maturity only at seven years old. From there on, the yield can gradually grow until the age of 15, when they stabilize. This may have been one of the factors responsible for the variation presented in yield per tree among plants of the same cultivar.

Although, 'Pomelo' produced less fruits per plant, its productivity was the same as the other varieties probably due to a greater fruit fresh mass (r = 0.60, p < 0.05), length (r = 0.66, p < 0.05) and fruit width (r = 0.58, p < 0.01) obtained by this cultivar. The average values of fresh mass (108.7 g), length (48.8 mm) and fruit width (61.3 mm) of 'Rama Forte' and 'Rubi' were significantly lower.

There were no pH differences among all the sorts of crop, with an average value of 5.41. The value obtained for 'Fuyu' persimmon fruit (5.33) in this study was lower than the one observed by Brackmann et al. (2013) in Rio Grande do Sul, Brazil. The 'Rama Forte' persimmon fruit in this study show similar results with the same crops growing in Jundiaí (São Paulo, Brazil) conditions (Mendonça et al., 2015). These results can be due to climate condition variations and experimental site, but could be also due to the fruit's ripening stage and harvesting season.

The soluble solids content also did not differ among the cultivars, with an average value of 20.48 °Brix. This value is higher than those obtained in 'Rama Forte' and 'Mikado' persimmon fruits grown in Nova Friburgo (Rio de Janeiro, Brazil) which presented, for the same characteristic, average values of 14.0 and 14.8 °Brix, respectively (Shimizu et al., 2002). Results obtained by Vieites et al. (2012) with 'Giombo' persimmon fruits grown in Avaré (São Paulo, Brazil) showed lower soluble solids content (19.33 °Brix) as compared to the current study.

Soluble solids content ranging from 14.1 to 16.1 °Brix were obtained in 'Fuyu' persimmon fruits growing in Porto Amazonas (Paraná, Brazil) and Andosol (Japan) (Porfírio-da-Silva et al., 2011; Tetsumura et al., 2015). Those values were lower than the ones obtained for all crops in the current study. The differences among the sorts of crops may be related to edaphoclimatic factors, crop cultural handling methods, fruits ripening index and postharvest storage (Krammes et al., 2005; Porfírio-da-Silva et al., 2011), which imply modifications in fruits, as well as in the conversion of sugars, synthesis of soluble molecules in the cell wall and organic acid balance (Murray and Valentini, 1998).

Regarding the acidity, 'Pomelo' persimmon fruit had the lowest value in this trait (0.11% malic acid), while the highest value was obtained in 'Rama Forte' (0.14% malic acid). Both had opposite effect for ripening index, 'Pomelo' showed higher index value than 'Rama Forte' ones, with average values of 181.8 and 145.5, respectively, due to the high negative correlation between acidity and maturation index (r = -0.82, p < 0.01). With average values of 0.12 and 0.13% in titratable acidity, and 176.1 and 159.1 in the ripening index, 'Ruby' and

'Fuyu' persimmon fruits, respectively obtained intermediate values.

Persimmons are classified as climacteric fruits, and their organic acids (malic, citric and tartaric acids) can be metabolized, being intermediate compounds of cellular respiration for energy production, and can also be converted to soluble sugars, such as glucose, fructose and sucrose. These metabolic activities may sometimes, during the natural process of fruit ripening or storage for instance, be correlated and explain differences in acidity such as the ones observed throughout the study (Porfírio-da-Silva et al., 2011).

Conclusion

Despite the differences between the time periods of some intermediate phenological phases, the time required from pruning to the harvesting of the fruits is similar among the cultivars. 'Rama Forte' and 'Fuyu' cultivars produce more fruit per plant; however 'Pomelo' produces larger fruits, which are heavier and with less acidity.

Conflict of interests

The authors have not declared any conflict of interest.

REFERENCES

Agustí M (2010). Fruticultura, 2nd ed. Mundi-Prensa, Espanha.

Biasi LA, Peressuti RA, Telles CA, Zanette F, Mio LLM (2007). Qualidade de frutos de caqui 'Jiro' ensacados com diferentes embalagens. Semin. Ciênc. Agrár. 28(2):213-218.

Brackmann A, Schorr MRW, Gasperin AR, Venturini TL, Pinto JAV (2013). Controle da maturação de caqui 'Fuyu' com aplicação de aminoetoxivinilglicina e 1-metilciclopropeno. Rev. Bras. Frutic. 35(4):953-961.

Campos SS (2014). Fenologia, estudo da biologia floral, fertilidade do pólen e produção em cultivares de caquizeiro (*Diospyros kaki* L. e *Diospyros virginiana* L.). Dissertation (Master's degree in plant science) - Universidade Federal do Rio Grande do Sul 65 p.

Campos SS, Wittmann MTS, Schwarz SF, Veit PA (2015). Biologia floral e viabilidade de pólen em cultivares de caquizeiro (*Diospyros kaki* L.) e *Diospyros virginiana* L. Rev. Bras. Frutic. 37(3):685-691.

Candir EE, Ozdemir AE, Kaplankiran M, Toplu C (2009). Physico-chemical changes during growth of persimmon fruits in the East Mediterranean climate region. Sci. Hortic. 121:42-48.

CEPAGRI – Centro de Pesquisas Meteorológicas e Climáticas Aplicadas à Agricultura (2016). Clima dos municípios paulistas. Centro de Pesquisas Meteorológicas e Climáticas aplicadas à Agricultura. http://www.cpa.unicamp.br/outras-informacoes/clima_muni_086.html. Accessed in April 29th 2016.

Corrêa MCM, Prado RM, Natale W, Silva MAC, Pereira L (2002). Índice de pegamento de frutos em goiabeiras. Rev. Bras. Frutic. 24(3):783-786.

Corsato CE, Scarpare Filho JA, Verdial MF (2005). Fenologia do caquizeiro "Rama Forte" em clima tropical. Bragantia 64(3):323-329.

EMBRAPA – Empresa Brasileira de Pesquisa Agropecuária (2006). Sistema Brasileiro de Classificação de Solos, in: Centro Nacional de Pesquisa de Solos. Embrapa Solos, Rio de Janeiro 306 p.

Ferreira DF (2011). Sisvar: a computer statistical analysis system. Ciênc. Agrotec. 35:1039-1042.

García-Carbonell S, Yagüe B, Bleiholder H, Hack H, Meier U, Agustí M (2002). Phenological growth stages of the persimmon tree (*Diospyros kaki*). Ann. Appl. Biol. 141:73-76.

George AP, Mowat AD, Collins RJ, Morley-Bunker M (1997). The pattern and control of reproductive development in non-astringent persimmon (*Diospyros kaki* L.): a review. Sci. Hortic. 70:93-122.

IEA – Instituto de Economia Agrícola (2016). Estatísticas da produção paulista. http://www.iea.sp.gov.br/out/index.php. Accessed in March 22th 2016.

Krammes JG, Argenta LC, Vieira MJ (2005). Controle da maturação e conservação da qualidade pós-colheita de caqui 'Fuyu' pelo manejo do etileno. Rev. Bras. Frutic. 27(3): 360-365.

Mendonça VZ, Daiuto ER, Furlaneto KA, Ramos JA, Fujita E, Vieites RL, Tecchio MA, Carvalho LR (2015). Aspectos físico-químicos e bioquímicos durante o armazenamento refrigerado do caqui em atmosfera modificada passiva. Nativa 3(1):16-21.

Murray R, Valentini G (1998). Storage and quality of peach fruit harvest at different stages of maturity. Acta Hortic. 2:455-463.

Ojima M, Dall'Orto FAC, Barbosa W, Tombolato AFC, Rigitanom O (1985). Frutificação alternada em caqui cultivar Pomelo (IAC 6-22). Bragantia 44(1):481-486.

Pereira FM, Kavati R (2011). Contribuição da pesquisa científica brasileira no desenvolvimento de algumas frutíferas de clima subtropical. Rev. Bras. Frutic. 33:92-108.

Pio R (2014). Cultivo de fruteiras de clima temperado em regiões subtropicais e tropicais, 1st ed. Editora UFLA, Lavras.

Porfírio-da-Silva LC, Almeida MM, Borsato AV, Raupp DS (2011). Qualidade pós-colheita do caqui 'Fuyu' tratado com a promalina. Acta Sci. Agron. 33(3):519-526.

Shimizu MK, Coneglian RCC, Busquet RNB, Castricini A (2002). Avaliação do efeito de diferentes concentrações de álcool na destanização e amadurecimento de caqui. Agronomia 36(1/2):11-16.

Silva MC, Atarassi ME, Ferreira MD, Mosca MA (2011). Qualidade pós-colheita de caqui 'Fuyu' com utilização de diferentes concentrações de cobertura comestível. Ciênc. Agrotec. 35(1):144-151.

Silva FS, Azevedo CAV (2002). Versão do programa computacional ASSISTAT para o sistema operacional Windows. Rev. Bras. Prod. Agroind. 4:71-78.

Souza EL, Argenta LC, Souza ALK, Pereira Gardin JP, Nunes EO, Rombaldi CV (2011). Produtividade e qualidade de caqui na colheita e após armazenamento refrigerado com aplicação de diferentes doses de nitrogênio no solo. Evidência 11(1):19-32.

Tetsumura T, Ishimura S, Hidaka T, Hirano E, Uchida H, Kai Y, Kuroki S, Uchida Y, Honsho C (2015). Growth and production of adult Japanese persimmon (*Diospyros kaki*) trees grafted onto dwarfing rootstocks. Sci. Hortic. 187:87-92.

Veberic R, Jurhar J, Mikulic-Petkovsek M, Stampar F, Schmitzer V (2010). Comparative study of primary and secondary metabolites in 11 cultivars of persimmon fruit (*Diospyros kaki* L.). Food Chem. 119:477-483.

Vieira MJ, Argenta LC, Aramante CVT, Steffens CA, Souza EL (2016). Conservação de caqui 'Fuyu' com o tratamento em pré-colheita e pós-colheita com 1-metilciclopropeno. Pesqui. Agropecu. Bras. 51(3):197-206.

Vieites RL, Picanço NFM, Daiuto ER (2012). Radiação gama na conservação de caqui 'Giombo', destanizado e frigoarmazenado. Rev. Bras. Frutic. 34(3):719-726.

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Factors associated with weed occurrence in Southwest region of Goiás

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After the introduction of Roundup Ready® technology, there were changes in community composition of weeds in the Southwest of Goiás. In this sense, this study aimed at evaluating weed distribution in different cropping systems in this region. Thus, phytosociological survey was conducted in three different periods. Studies were conducted on thirty-five areas derived from combined soybean crops resistant to glyphosate and conventional soybean, maize, sorghum, millet or fallow in succession. The number of individuals of weeds, dry biomass of soil surface and edaphoclimatic data was obtained in order to describe the variables responses of floristic composition. The factors associated to the total occurrence of species were evaluated and five species difficult to control (*Cenchrus echinatus*, *Alternanthera tenella*, *Chamaesyce hirta*, *Euphorbia heterophylla* e *Glycine max*) in regression analysis on tree were selected. A total of 3,219 individuals among 79 species were recorded. Regarding total occurrence of species period desiccation of main crop pre-planting (44.80 pl. 5 m^2) and on sites that showed pH> 5,37 (51.20 pl. 5 m^2) had higher infestations. Voluntary soybean was found in off-season, preferably with high sand content. Species of hard control, tolerant or resistant to herbicides were diagnosed in areas study.

Key words: Soybean, tolerance, herbicide.

INTRODUCTION

In Brazil, the cultivation of genetically modified soybean for glyphosate resistance significantly changes the chemical control mechanisms and management in more than 25 million of hectares. This fact associated to the second crop cultivation is the main change diagnosed in Brazilian agricultural systems focused on grain production. These changes have influenced over the years on floristic composition and dynamics of weed communities in different rotation/succession systems of cultures (Balbinot Jr and Veiga, 2014).

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Herbicides are the main selection factors of spontaneous plants. In sites where for several years herbicides recommended for the cultivation of conventional soybeans were applied, as imazethapyr, chlorimuron-ethyl, fomesafen, lactofen, haloxyfop-methyl, fluazifop-p-butyl, clethodim, among others, received only glyphosate applications during soybean cycle. This substitution of herbicides has been promoting a change in weed community of agricultural areas. However, this change has not yet been quantified and scientifically qualified in the different Brazilian regions.

In American agriculture, tillage system and intensive glyphosate use in areas of transgenic crops significantly influence composition and weed populations (Swanton et al., 1993; Shaner, 2000). Besides the use in post-emergency in crops with induced resistance, glyphosate is widely used in desiccation operations in pre-planting.

In addition to the use of Roundup Ready® technology, another factors such as local conditions: type of soil, climate, cropping practices, seed bank and more recently the occurrence of tolerant weeds and or resistant to herbicide application, are also associated to occurrence of spontaneous plants in agricultural ecosystems (Adegas et al., 2010). Researchers found that in no-tillage system, some invasive species such as *Spermacoce latifolia*, *Synedrellopsis grisebachii*, *Commelina benghalensis* and *Tridax procumbens* have been selected due to successive applications of glyphosate in cerrado agricultural areas (Procópio et al., 2007). Other weed species were also reported to be tolerant to herbicides, detaching: *Ambrosia artemisiifolia* (Kapusta et al., 1994), *Sesbastiania exaltata*, *Ipomoea* spp. (Jordan et al., 1997; Lich et al., 1997).

In view of these findings, the glyphosate efficiency, which is herbicide of broad spectrum action mainly used in soybean crop under no-tillage system, in less than a decade of use, is threatened by species occurrence of tolerant and resistant weeds (Webster and Sosnoskie, 2010).

In the southwest region of Goiás, areas that were intended for conventional soybean cultivation, adopted no-tillage system with cultivation of two annual harvests. Soybean is cultivated at the beginning of rainy season and maize, millet and sorghum in the second season (off-season). Changes in chemical control mechanisms and management, promoted by the cultivation of genetically modified soybean and second harvest crops for production of grain and dry biomass of soil surface, associated to edaphoclimatic conditions have influenced floristic composition and weed establishment in this region.

Considering this set of factors, this study aimed at evaluating floristic composition and structure of weed community in different soybean production systems in the Southwest region of Goiás, as well to determine the factors associated to species occurrence considered difficult to control, recorded in the Southwest region of Goiás.

MATERIALS AND METHODS

Studies were conducted in the Southwest of Goiás, in agricultural areas of Rio Verde, Santa Helena de Goiás, Montividiu and Santo Antonio da Barra municipalities, in the crop year of 2012/2013, from June 2012 to July 2013. Regarding Köppen and Gêiser classification, sites have AW climate: with average temperatures from 23.0 to 24.3 °C and average annual rainfall from 1,510 to 1,663 mm, with the highest concentration in the summer. Winter is dry with mild temperatures and absence of rain between May and September. Soils are Red Latosol Distroferric and Red Latosol Dystrophic types (Santos et al*.,* 2011).

The phytosociological survey was conducted in seven production systems (treatments) with five replications in different properties, which had at least three consecutive years of deployment, totaling thirty-five agricultural areas (Table 1). In these properties, the cultivation of modified soybean for resistance to glyphosate (RR Soybean) and conventional soybeans in crop, with successions of maize, sorghum and millet or fallow in off-season is predominant.

Soil samples were collected in plots of twenty hectares at a depth of 0 or 10 cm, prior to correction activities for summer yield deployment. Twelve single samples to obtain a complete sample were taken. Soil fertility data were used in occurrence correlation of weed species (Table 2).

The field survey was conducted in three evaluation periods: before desiccation for soybean crop deployment; prior to the first herbicides application on post-emergence in soybean crop at twenty days after sowing; prior to the first herbicides application on post-emergence in soybean crop at twenty days after off-season crop deployment, or in fallow area. Weeds were inventoried from the random release of hollow frames (0.5 x 0.5 m) in sample areas and phytosociological analysis based on Braun-Blanquet methodology (1979).

Considering the three seasons of field survey, twenty sampling units in each of five replications were standardized (5 m^2 per period or 15 m^2 total), totaling 100 units per treatment (25 m^2 per period or 75 m^2 total) and 700 sampling units in each survey stage (175 m^2 per period or 525 m^2 total) in 2,100 sampled hollow squares (Table 3).

Weeds present in squares were cut close to the soil and transferred to laboratory for identification and accounting of individual number per species. After botanical identification, it was placed in paper bags to determine the shoot dry biomass, by drying in forced ventilation at 65°C for 72 h and weighted on precision scale.

During phytosociological survey, straw samples of soil surface in hollow square delimitations on each sample unit were collected. Material was placed in cloth bags and dried in air forced ventilation for 72 h at 65°C for determination soil surface dry weight and estimative in tonnes per hectare. The obtained data of the number of individuals per species, shoot dry biomass of weeds and straw dry biomass of soil surface were used in species occurrence analyses according to variables responses of floristic composition.

Field data were processed from the PC-ORD 6.1 Software (McCune and Mefford, 2011). It was created a multivariate matrix for each variable responses descriptors of total floristic composition of the study. The multivariate analyses of tree regression was (multivariate regression tree model) (De'Ath, 2002) was used to model the variable responses depending on type of soybean factors (RR and conventional), crop succession, and edaphoclimatic covariates.

This analysis was performed to describe what combination of factors and its respective levels were associated to changes in response variable, as well relative importance of each one of these

Table 1. Properties localization of weed survey on agricultural region of Goiás Southwest. RR soybeans (glyphosate-tolerant soybeans) CV soybeans (conventional soybeans).

Treatments			Areas	Localization	Height (m)	Municipalities/Goiás
N°.	Soybeans/summer	Late harvest		Coordinates UTM (Universal Transversa de Mercator)		
1	RR Soybean	Maize	1	22 k 482613.93/8100304.26	862	Montividiu
1	RR Soybean	Maize	2	22 k 540809.09/8008785.91	639	Rio Verde
1	RR Soybean	Maize	3	22 k 524462.03/8019154.20	635	Rio Verde
1	RR Soybean	Maize	4	22 k 560434.78/8044516.10	557	Santa Helena
1	RR Soybean	Maize	5	22 k 528012.52/8021719.00	627	Rio Verde
2	RR Soybean	Millet	2	22 k 503225.37/8077848.74	828	Rio Verde
2	RR Soybean	Millet	3	22 k 505769.78/8079871.48	799	Montividiu
2	RR Soybean	Millet	4	22 k 506350.89/8079876.84	768	Montividiu
2	RR Soybean	Millet	5	22 k 524439.59/8016860.74	626	Rio Verde
2	RR Soybean	Millet	1	22 k 482278.90/8083495.89	874	Montividiu
3	RR Soybean	Sorghum	1	22 k 532499.20/8030623.97	685	Santa Helena
3	RR Soybean	Sorghum	2	22 k 525340.12/8020605.52	629	Rio Verde
3	RR Soybean	Sorghum	3	22 k 480231.77/8099772.54	847	Montividiu
3	RR Soybean	Sorghum	4	22 k 503766.73/8078668.74	792	Montividiu
3	RR Soybean	Sorghum	5	22 k 560464.02/8042437.67	530	Santa Helena
4	RR Soybean	Fallow	1	22 k 502135.51/8079836.23	756	Rio Verde
4	RR Soybean	Fallow	2	22 k 503231.39/8080329.71	768	Rio Verde
4	RR Soybean	Fallow	3	22 k 481486.73/8099463.40	858	Montividiu
4	RR Soybean	Fallow	4	22 k 480977.40/8099669.14	863	Montividiu
4	RR Soybean	Fallow	5	22 k 506231.98/8044023.95	832	Rio Verde
5	CV Soybean	Maize	1	22 k 500502.47/8079165.26	753	Montividiu
5	CV Soybean	Maize	2	22 k 500701.46/8079859.67	750	Montividiu
5	CV Soybean	Maize	3	22 k 526129.0/8018108.76	666	Rio Verde
5	CV Soybean	Maize	4	22 k 525957.64/8018272.84	660	Rio Verde
5	CV Soybean	Maize	5	22 k 518887.66/8019237.99	650	Rio Verde
6	CV Soybean	Millet	1	22 k 525933.31/8018614.52	654	Rio Verde
6	CV Soybean	Millet	2	22 k 526285.71/8018965.53	653	Rio Verde
6	CV Soybean	Millet	3	22 k 540987.37/8057939.34	569	St. Antônio da Barra
6	CV Soybean	Millet	4	22 k 541670.84/8058093.42	574	St. Antônio da Barra
6	CV Soybean	Millet	5	22 k 541911.35/8057517.36	584	St. Antônio da Barra
7	CV Soybean	Sorghum	1	22 k 525763.47/8018402.43	651	Rio Verde
7	CV Soybean	Sorghum	2	22 k 540645.54/8073577.33	608	St. Antônio da Barra
7	CV Soybean	Sorghum	3	22 k 540331.35/8073928.66	617	St. Antônio da Barra
7	CV Soybean	Sorghum	4	22 k 507115.76/8044911.38	779	Rio Verde
7	CV Soybean	Sorghum	5	22 k 506929.16/8044116.21	819	Rio Verde

factors.

Univariate version of regression tree models (De' Ath and Fabricius, 2000) was used to model the incidence of weeds separately depending on the factors mentioned above. This same approach was used for statistical analysis to evaluate matrices containing only a data subset concerning to most problematic weed control. The components species of this subset were selected after floristic composition survey of areas. The distribution and total occurrence of species were analyzed and five were selected (*Cenchrus echinatus, Alternanthera tenella, Chamaesyce hirta, Euphorbia heterophylla* and *Glycine max*) considered difficult to control in the study areas, in the application of tree regression analysis.

RESULTS AND DISCUSSION

A total of 3,219 individuals among 79 species of weeds, which amounted 5,815.74 g of shoot dry matter weight, were surveyed (Table 4). There was a variation in the number of individuals and dry weight of shoot in the different evaluation times, predominantly higher values in period prior desiccation for soybean sowing, with a decrease in the period prior to the post-emergence application of soybean and smooth stabilization in performed survey earlier to post-emergence application

Table 2. Soil analyzes results in the depth from 0 to 10 performed in propertiesof the agricultural region of Goiás Southwest.

Treatments			Rep.	$Cmol_c dm^{-3}$						$mgdm^{-3}$		gkg^{-1}	pH	m%	V%	$Cmol_c dm^{-3}$		Clay	Silte	Sand	($mgdm^{-3}$)			
N°.	Soybean/summer	Late harvest		Ca+Mg	Ca	K	Mg	Al	H+Al	K	P(Mel)	M.O.	$CaCl_2$			CTC	SB				Fe	Mn	Cu	Zn
Treat. 1	RR Soybean	Maize	1	3.34	2.25	0.13	1.09	0.01	2.35	51.00	9.89	20.59	5.54	0.29	59.68	5.82	3.47	19.34	11.87	68.79	86.67	28.15	1.25	7.33
Treat. 1	RR Soybean	Maize	2	4.62	3.48	0.24	1.14	0.01	3.71	95.50	26.79	22.56	5.72	0.21	56.62	8.57	4.86	26.47	6.52	67.00	37.83	169.53	1.20	6.10
Treat. 1	RR Soybean	Maize	3	3.88	2.91	0.16	0.97	0.01	3.09	63.00	2.27	31.35	5.71	0.25	56.66	7.14	4.04	42.46	25.04	32.49	74.88	71.46	1.86	3.07
Treat. 1	RR Soybean	Maize	4	2.72	2.09	0.21	0.63	0.08	7.71	81.50	14.74	31.74	5.39	3.42	27.93	10.64	2.93	54.30	25.76	19.95	32.13	125.45	0.94	2.49
Treat. 1	RR Soybean	Maize	5	3.16	2.53	0.12	0.63	0.01	4.62	48.00	14.02	20.86	5.17	0.31	41.45	7.91	3.29	32.33	5.07	62.60	83.89	54.36	1.83	2.46
Treat. 2	RR Soybean	Sorghum	1	3.24	2.57	0.19	0.67	0.01	5.03	75.50	5.48	24.06	5.44	0.30	40.27	8.47	3.43	43.66	7.52	48.82	104.44	23.85	1.86	3.10
Treat. 2	RR Soybean	Sorghum	2	4.22	3.11	0.43	1.11	0.03	4.87	168.50	14.72	30.84	5.34	0.74	48.72	9.52	4.65	50.43	13.58	35.99	99.03	29.37	0.88	2.90
Treat. 2	RR Soybean	Sorghum	3	2.07	1.52	0.23	0.55	0.13	4.00	89.00	11.04	9.34	5.01	8.59	34.82	6.30	2.30	21.48	4.62	73.90	73.95	98.82	1.31	4.33
Treat. 2	RR Soybean	Sorghum	4	3.10	2.30	0.19	0.79	0.03	3.05	76.00	11.61	17.09	5.13	0.99	51.72	6.35	3.29	20.39	4.66	74.95	104.49	110.46	1.78	4.40
Treat. 2	RR Soybean	Sorghum	5	3.60	2.37	0.34	1.22	0.05	4.79	132.00	2.41	28.99	5.24	1.28	44.89	8.72	3.93	47.11	13.49	39.40	102.09	127.05	4.96	2.61
Treat. 3	RR Soybean	Millet	1	5.60	4.47	0.14	1.13	0.01	5.24	55.50	12.05	34.23	5.47	0.19	52.50	10.98	5.74	30.97	22.69	46.33	30.11	146.82	1.37	3.77
Treat. 3	RR Soybean	Millet	2	4.50	3.58	0.39	0.92	0.01	3.80	154.00	7.32	26.61	5.86	0.21	56.13	8.69	4.89	39.98	26.08	33.94	85.51	94.86	4.89	3.73
Treat. 3	RR Soybean	Millet	3	4.61	4.06	0.20	0.55	0.01	1.86	77.00	9.89	17.15	5.91	0.22	71.45	6.66	4.80	8.34	15.06	76.60	109.37	20.97	1.17	5.06
Treat. 3	RR Soybean	Millet	4	4.49	3.19	0.21	1.30	0.01	4.91	82.50	13.57	33.52	5.72	0.22	48.45	9.61	4.70	49.12	13.24	37.64	101.03	32.58	0.20	2.30
Treat. 3	RR Soybean	Millet	5	4.84	4.05	0.33	0.79	0.01	5.57	130.50	6.72	25.85	5.77	0.20	47.69	10.75	5.18	52.90	20.38	26.72	40.85	148.29	5.01	1.72
Treat. 4	RR Soybean	Fallow	1	4.04	2.62	0.33	1.42	0.01	4.87	129.50	5.09	32.28	5.21	0.25	46.93	9.24	4.38	58.82	22.56	18.62	41.13	154.65	13.79	3.47
Treat. 4	RR Soybean	Fallow	2	3.94	2.65	0.33	1.29	0.03	5.82	129.00	7.39	29.49	5.39	0.69	42.31	10.08	4.27	43.37	5.92	50.71	51.72	146.01	5.41	3.26
Treat. 4	RR Soybean	Fallow	3	2.72	2.54	0.09	0.17	0.01	1.49	36.00	16.35	12.15	5.74	0.38	64.81	4.30	2.81	11.20	4.67	84.13	91.47	13.17	1.62	4.03
Treat. 4	RR Soybean	Fallow	4	3.52	3.27	0.25	0.25	0.01	0.91	98.00	11.95	18.06	5.89	0.28	80.58	4.68	3.77	13.99	6.08	79.93	99.81	19.17	1.68	5.23
Treat. 4	RR Soybean	Fallow	5	2.62	2.02	0.05	0.61	0.01	3.18	21.00	10.80	22.21	5.39	0.39	46.05	5.85	2.68	26.90	2.95	70.16	67.12	51.42	1.13	14.32
Treat. 5	CV Soybean	Maize	1	2.85	2.16	0.18	0.70	0.01	3.22	72.00	19.31	20.01	5.37	0.35	48.19	6.26	3.04	20.62	6.96	72.43	52.59	83.73	2.99	11.84
Treat. 5	CV Soybean	Maize	2	2.48	1.98	0.10	0.50	0.01	2.10	39.00	14.37	15.46	5.35	0.39	55.10	4.68	2.58	11.91	1.67	86.42	54.02	58.45	1.47	8.65
Treat. 5	CV Soybean	Maize	3	3.52	2.85	0.23	0.67	0.01	4.66	88.50	13.54	27.93	5.23	0.27	44.52	8.40	3.74	37.88	9.00	53.12	25.74	96.41	2.60	9.81
Treat. 5	CV Soybean	Maize	4	2.66	2.25	0.22	0.40	0.01	4.83	85.50	8.86	29.62	5.03	0.35	37.42	7.70	2.88	36.37	8.90	54.73	32.38	69.76	2.23	10.86
Treat. 5	CV Soybean	Maize	5	2.63	2.10	0.11	0.53	0.01	5.40	44.50	6.81	33.65	4.92	0.36	33.72	8.15	2.75	60.69	21.23	18.08	49.44	59.03	2.69	6.90
Treat. 6	CV Soybean	Millet	1	2.28	2.00	0.18	0.28	0.01	4.66	69.00	10.77	24.73	5.15	0.41	34.51	7.12	2.46	33.36	4.43	62.22	51.61	67.93	2.56	7.91
Treat. 6	CV Soybean	Millet	2	2.43	2.10	0.12	0.33	0.01	4.83	45.00	11.88	26.13	5.21	0.40	34.38	7.37	2.54	38.69	7.39	53.92	93.30	83.07	3.46	7.54
Treat. 6	CV Soybean	Millet	3	5.08	3.68	0.38	1.40	0.01	4.50	150.00	8.16	41.93	5.41	0.18	54.77	9.96	5.46	64.45	16.60	18.95	65.86	144.30	6.31	3.59
Treat. 6	CV Soybean	Millet	4	4.21	2.75	0.27	1.46	0.01	4.41	105.00	4.27	43.08	5.62	0.24	49.61	8.89	4.48	58.99	18.34	22.66	31.51	110.19	5.10	4.64
Treat. 6	CV Soybean	Millet	5	3.53	2.62	0.12	0.91	0.03	6.02	45.00	4.84	41.42	5.50	0.99	37.38	9.67	3.65	76.07	12.77	11.16	37.32	360.12	4.49	2.76
Treat. 7	CV Soybean	Sorghum	1	2.81	2.25	0.15	0.56	0.01	3.34	60.00	4.06	29.62	5.20	0.34	46.96	6.30	2.96	32.00	12.60	55.40	55.20	61.35	3.59	4.58
Treat. 7	CV Soybean	Sorghum	2	2.57	2.04	0.11	0.53	0.01	2.89	42.00	14.97	17.84	5.32	0.38	47.98	5.56	2.67	24.45	4.49	71.06	45.96	50.28	2.06	3.41
Treat. 7	CV Soybean	Sorghum	3	2.86	2.19	0.10	0.67	0.01	3.18	40.50	17.92	20.14	5.41	0.34	48.22	6.14	2.97	27.98	3.11	68.91	45.42	61.88	1.91	3.71
Treat. 7	CV Soybean	Sorghum	4	2.51	1.94	0.14	0.56	0.01	3.42	56.50	26.07	17.97	5.42	0.39	43.49	6.08	2.65	12.09	1.70	86.21	84.10	60.00	1.09	11.09
Treat. 7	CV Soybean	Sorghum	5	2.02	1.59	0.20	0.44	0.01	3.88	78.50	17.25	18.99	5.18	0.52	35.91	6.10	2.23	22.07	4.66	73.27	59.47	38.39	2.41	10.78

RR Soybean: genetically modified soybean for resistance to glyphosate; CV Soybean: Conventional Soybean.

Table 3. Sampling areas of the weed survey in the southwestern region of Goiás.

Treatments		Seasons 1		Seasons 2		Seasons 3		Total	
		Number squares	Area (m^2)	Number squares	Area (m^2)	Number squares	Area (m^2)	Number squares	area (m^2)
Treat. 1	RR Soybean + Maize	100	25	100	25	100	25	300	75
Treat. 2	RR Soybean + Millet	100	25	100	25	100	25	300	75
Treat. 3	RR Soybean + Sorghum	100	25	100	25	100	25	300	75
Treat. 4	RR Soybean + Fallow	100	25	100	25	100	25	300	75
Treat. 5	CV Soybean + Maize	100	25	100	25	100	25	300	75
Treat. 6	CV Soybean + Millet	100	25	100	25	100	25	300	75
Treat. 7	CV Soybean + Sorghum	100	25	100	25	100	25	300	75
	Total	700	175	700	175	700	175	2100	525

Table 4. Number of individuals distribution (NI) and shoot dry biomass (DB) of weed species in Southwest of Goiás.

Family	Espécies	Comum name	Bayer Code	US Code	NI	DB (g)
Poaceae	*Cenchrus echinatus* L.	Sandbur, southern	CCHEC	CEEC	680	1,589.75
Asteraceae	*Conyza bonariensis* (L.) Cronq.	Fleabane, hairy	ERIBO	COBO	44	398.78
Amaranthaceae	*Alternanthera tenella* Colla	Joyweeds	-	-	244	367.41
Malvaceae	*Sida glaziovii* K. Schum	Malva	-	-	134	366.72
Asteraceae	*Praxelis pauciflora* (Kunth) R. M.King e H. Rob.	Anil	-	-	60	198.82
Commelinacea	*Commelina benghalensis* L	Dayflower, Benghal	COMBE	COBE2	261	193.92
Malvaceae	*Malvastrum coromandelianum* (L.) Garcke	False mallow, broom weed	-	-	39	152.24
Asteraceae	*Conyza canadensis* (L.) Cronq.	Horseweed	ERICA	COCA5	48	151.66
Euphorbiaceae	*Chamaesyce hirta* (L.) Millsp.	Spurge, garden	EPHHI	CHHI3	276	146.7
Poaceae	*Eleusine indica* (L.) Gaertn.	Goosegrass	ELEIN	ELIN3	112	143.46
Poaceae	*Panicum maximum* Jacq.	See *Urochloa maxima*	PANMA	PAMA4	13	138.99
Malvaceae	*Sida rhombifolia* L	Sida, arrowleaf	SIDRH	SIRH	48	136.92
Asteraceae	*Bidens subalternans* DC.	Picão-preto	-	-	176	111.68
Asteraceae	*Tridax procumbens* L.	Buttons, coat	TRQPR	TRPR5	56	103.21
Poaceae	*Digitaria insularis* (L.) Mez ex Ekman	Sourgrass	TRCIN	DIIN2	44	94.55
Poaceae	*Setaria parviflora* (Poir.) Kerguélen	Foxtail, knotroot	SETGE	SEPA10	22	91.71
Smilacaceae	*Smilax polyantha* Griseb.	Smilaxes	-	-	9	86.61
Fabaceae	*Glycine max* (L.) Merr.	Soybean	-	GLMA4	284	85.89
Cyperaceae	*Cyperus difformis* L.	Sedge, smallflower umbrella	CYPDI	CYDI4	85	79.21
Poaceae	*Pennisetum setosum* (Sw). Rich.	Fountain grass	-	-	45	74.39
Polygonaceae	*Rumex obtusifolius* L.	Dock, broadleaf	RUMOB	RUOB	2	22.46

Table 4. Contd.

Smilacaceae	*Smilax campestris* Griseb.	Catbriers,greenbriers, pricklyivys, and smilaxes	-	-	3	21.65
Poaceae	*Digitaria ciliaris* (Retz.) Koel.	Crabgrass, southern	DIGSP	DICA	5	19.51
Solanaceae	*Solanum americanum* P. Mill.	Nightshade, American black	SOLAM	SOAM	5	19.42
Asteraceae	*Acanthospermum hispidum* DC.	Starbur, bristly	ACNHI	ACHI	2	18.65
Boraginaceae	*Heliotropium indicum* L.	Heliotrope, Indian	HEOIN	HEIN	1	16.51
Euphorbiaceae	*Cnidoscolus urens* (L.) Arthur	Bull nettle', 'spurge, nettle', or 'mala mujer' (evil woman).	-	-	1	15.13
Myrtaceae	*Eugenia* sp.	Cagaita	-	-	3	15.03
Lamiaceae	*Leonotis nepetifolia* (L.) R. Br.	Lionsear	LEONE	LENE	12	15.00
Mennispermaceae	*Cissampelos sp1*	Orelha-de-onça	-	-	9	14.73
Malvaceae	*Sida cordifolia*	Sida, heartleaf	SIDCO	SICO	5	12.45
Asteraceae	*Synedrellopsis grisebachii* Hieron & Kuntze	Straggler daisy	-	-	3	12.41
Asteraceae	*Bidens pilosa* L.	Beggarticks, hairy	BIDPI	BIPI	6	11.04
Poaceae	*Pennisetum americanum* (L.) Leeke	Millet	-	-	16	10.44
Polygonaceae	*Rumex acetosella* L.	Sorrel, red	RUMAA	RUAC3	6	9.38
Myrtaceae	*Myrcia guianensis* (Aubl.) DC.	Birch, bois de fer, bois de Ste. Lucie, bois petite, feuille, guava berry	-	-	2	7.90
Crhysobalanaceae	*Couepia grandiflora* Benth.	Oiti	-	-	1	7.63
Lamiaceae	*Heteropterys sp.*	-----	-	-	3	7.29
Malvaceae	*Sida urens* L.	Tropical fanpetals, balaizortie	-	-	3	7.19
Rubiaceae	*Spermacoce latifolia* Aubl.	Buttonweed	-	-	7	7.19
Fabaceae	*Senna obtusifolia* (L.) H. S. Irwin & Barneby	Sicklepod	CASOB	SEOB4	33	73.24
Mennispermaceae	*Cissampelos* sp 2	Orelha-de-onça	-	-	10	60.95
Poaceae	*Rhynchelytrum repens* (Willd.) C. E. Hubbard	See *Melinis repens*	RHYRE	RHRE2	15	49.93
Asteraceae	*Emilia fosbergii* Nichols.	Cupid's-shaving-brush	EMIFO	EMFO	6	47.97
Asteraceae	*Gnaphalium coarctatum* Willd	Cudweed	-	-	22	43.29
Convolvulaceae	*Ipomoea grandifolia* L.	Morning glory, sweet, potato, bindweed, moonflower	-	-	65	42.00
Fabaceae	*Crotalaria spectabilis* Roth	Crotalaria, showy	CVTSP	SRSP2	15	40.78
Smilacaceae	*Smilax brasiliensis* Spreng.	Catbriers, greenbriers, prickly-ivys, or, smilaxes	-	-	5	39.41
Poaceae	*Sorghum halepense* (L.) Pers.	Johnsongrass	SORHA	SOHA	1	38.00
Rubiaceae	*Richardia brasiliensis* (Moq.) Gomez	Pusley, Brazil	RCHBR	RIBR2	14	37.15
Euphorbiaceae	*Euphorbia heterophylla* L.	Poinsettia, wild	EPHHL	EUHE4	100	35.82
Poaceae	*Urochloa* sp.	Signalgrass, Dominican	-	-	11	35.19
Lamiaceae	*Mimosa hirsutissima* Mart.	Malicia	-	-	5	35.11
Amaranthaceae	*Amaranthus viridus* L.	Amaranth, slender	AMAVI	AMVI	13	33.79
Convolvulaceae	*Ipomoea cordifolia* L. (triloba)	Heart-leaved morning glory	-	-	46	33.49
Fabaceae	*Andira vermifuga* Mart. Ex Benth.	Angelim-do-cerrado	-	-	4	30.74
Mennispermaceae	*Cissampelos ovolifolia* DC.	Orelha-de-onça	-	-	8	28.41
Asteraceae	*Vernonia ferruginea Less.*	Ironweed	-	-	2	28.20

Table 4. Contd.

Poaceae	*Digitaria insularis* (L.) Mez ex Ekman	Sourgrass	TRCIN	DIIN2	21	26.81
Poaceae	*Zea mays* L.	Corn, volunteer	ZEAMX	ZEMA	16	24.07
Simaroubaceae	*Simaba* sp.	-----	-	-	1	6.72
Fabaceae	*Crotalaria incana* L.	Woolly rattlepod	-	-	1	6.68
Fabaceae	*Indigofera hirsuta* Harvey	Indigo, hairy	INDHI	INHI	6	5.61
Rubiaceae	*Spermacoce verticilata* L.	Shrubby false buttonweed	-	-	3	4.79
Smilacaceae	*Smilax ovolifolia* Roxb.	Common name, include catbriers, greenbriers, pricklyivys, and smilaxes	-	-	1	4.69
Moraceae	*Brosimum gaudichaudii* Trécul.	Mama-cadela	-	-	1	4.03
Nyctaginaceae	*Neea theifera* Oerst.	Nia, neea, or saltwood.	-	-	2	3.83
Malvaceae	*Sida spinosa*	Prickly fanpetals	SIDSP	SISP	1	1.75
Asteraceae	*Ageratum conyzoides* L.	Ageratum, tropic	AGECO	AGCO	1	1.40
Malvaceae	*Pavonia rosa-campestris* A. St. Hill	Rosa-vermelha	-	-	3	1.24
Asteraceae	*Cresta sphaerocephala* DC	João-bobo	-	-	1	1.20
Lamiaceae	*Hyptis lophanta* Mart. Ex Benth	Bushmint	-	-	1	1.16
Cyperaceae	*Cyperus odoratus* L.	Flatsedge	CYPFE	CYOD	1	1.05
Euphorbiaceae	*Phyllanthus tenellus* Roxb.	Phyllanthus, long-stalked	-	PHTE5	2	0.93
Anacardiaceae	*Lithraea molleoides* (Vell.) Engl.	Aroeira-brava	-	-	1	0.90
Connaraceae	*Connarus suberosus* L.	Pau-de-brinco	-	-	1	0.85
Vochysiaceae	*Qualea parviflora* Mart.	Pau-terra	-	-	1	0.45
Caesalpiniaceae	*Bauhinia* sp.	Orchid tree	-	-	1	0.31
Malvaceae	*Gossypum hirsutum* L.	Upland cotton or Mexican, cotton	-	-	3	0.19
	Total				3,219	5,815.74

of succession crop or second crop.

In this study, it was observed that the conventional soybean + maize treatment showed higher estimative (7.73 t ha^{-1}), followed by RR soybean + millet (6.79 t ha^{-1}) and RR soybean + maize (6.64 t ha^{-1}) (Table 5). The quantity of straw dry biomass on the soil and uniformity of its distribution are reference for qualitative assessment of no-tillage system. This system must have at least 6 t ha^{-1} to have sustainability (Alvarenga et al., 2001).

The combinations RR soybean + sorghum (4.51 t ha^{-1}); conventional soybean + millet (4.21 t ha^{-1}), conventional soybean + sorghum (4.91 t ha^{-1}) and RR soybean + fallow (4.0 t ha^{-1}) showed lower amounts of dry biomass of surface. These combinations showed amount of straw below the minimum necessary to maintain no-tillage system. This shows the need for higher production of dry biomass of soil recover straw in region. In addition, for the cerrado region notes enhanced rate of decomposition that is intensified by heat and humidity in soil.

In performed works in cerrado areas in Minas Gerais, Resende (1995) found a reduction in the production of straw biomass with delay in sowing time. This author reported average yields of straw of 6.44 and 5.84 t ha^{-1} for sorghum and millet, respectively. It is noteworthy that the means for millet were lower than data from this study on RR soybean (6.79 t ha^{-1}). Millet, according to Salton and Kiche (1998), produces variable dry biomass with edaphoclimatic conditions, sowing periods and time of cultivation and can reach 5 t ha^{-1} in less than 60 days.

Usually areas without plant coverage, in the period in which there is no commercial crops, tend to have weed infestations on subsequent cultivation (Silva and Silva, 2007). However, it

Table 5. Dry biomass of soil coverage straw (t ha^{-1}) in production systems in the Southwest region of Goiás.

Treatments		N. sp.	Straw (t ha^{-1})
Treat. 1	RR Soybean + maize	43	6.64
Treat. 2	RR Soybean + millet	44	6.79
Treat. 3	RR Soybean + sorghum	40	4.51
Treat. 4	RR Soybean + Fallow	35	4.00
Treat. 5	CV Soybean + maize	38	7.73
Treat. 6	CV Soybean + millet	30	4.21
Treat. 7	CV Soybean + Sorghum	18	4.91

N. sp.: number of species.

was recorded in this study that combinations: conventional soybean + maize, RR soybean + millet and RR soybean+ maize; which showed higher mean of dry weight of straw soil surface also showed a higher number of weed species (Table 5). In these treatments only straw surface is not enough to suppress weeds. The chemical management, with applications of grass herbicides in maize and millet in off-season period may be disabled. It is detached that in most analyzed areas, there was no chemical control in the fallow period which led to higher infestation in these off-season crops and increased herbicide applications in main culture.

Regarding total occurrence of weed species to tree containing four terminal nodes explained 51% of the total data variability in the occurrence of total weed data found in the Southwest of Goiás (Figure 1). The determining factor in this analysis was the evaluation periods, with higher weed infestation at desiccation pre-planting time of main crop (average of 44.80 plants per 5 m^2) compared to periods that precede post-emergence application in crop and/or off - season (average of 23.90 plants per 5 m^2).

During the second harvest period, the general infestation (average of 27.90 plants per 5 m^2) was higher than in the harvest (average of 20.00 plants per 5 m^2). The infestation of weeds in the period of pre-plant desiccation was associated to soil pH, and in soils with pH< 5.37 (average of 37.30 plants per 5 m^2). The data showed that desiccation is the time in which chemical control is more required due to the higher density of weeds, and also due to the development of species. Soils with more suitable pH ranges favor greater weed infestation, perhaps due to greater availability of nutrients observed in those soils, benefiting both crops and weed community.

Regarding the occurrence of *C. echinatus*, the tree with five terminal nodes explained 51% of the total variability of data occurrence (Figure 2). The most important factor associated to the occurrence of this species was the percentage of sand in the soil composition, with greater infestation in areas with sand content higher than 47.5% (average of 8.64 plants per 5 m^2) compared to other areas (average of 2.79 plants per 5 m^2). In areas containing sand content higher than 47.5%, the time of evaluation was also associated to the occurrence of *C. echinatus*, with 1 and 3 periods, desiccation in pre-sowing and post-emergence in off-season with the highest average (11.0 plants by 5 m^2) of *C. echinatus* at period 2 (yield, 3.86 plants per 5 m^2).

In more sandy areas greater than 47.5%, at periods 1 and 3, it was found that the amount of straw on soil surface was also associated to the occurrence of *C. echinatus.* Sites with dry straw under 2.7 t ha^{-1} showed higher infestation (average 12.70 plants per 5 m^2) compared to areas with more than 2.7 t $ha^{-1}$of straw (average 5.91 plants per 5m^2). In these areas, with low straw level on soil surface, survey periods were also an important factor to explain the occurrence of this species, a greater number of plants before pre-planting desiccation compared to off-season period was found. From this information, it can be summarized that more sandy areas with low straw biomass on surface facilitates the *C. echinatus* infestation especially at the period prior to pre-planting desiccation. This shows the low efficiency in off-season control in addition to the natural period of soil fallow. This species is an herbaceous grass of widespread occurrence throughout Brazil, and is considered one of the six most aggressive species in agriculture having great dispersion potential (Kissmann, 1997).

Regarding the factors associated to the occurrence of *A. tenella* the tree containing four terminal nodes explained 64% of the total variability of data occurrence (Figure 3). The most important factor was soil sand content, where there was the formation of two nodes, one indicating greater infestation of *A. tenella* in areas with sand content lower than 33.2% (average of 7.04 plants per 5 m^2) compared to areas with sand content higher than 33.2% (average of 0.92 plants per 5 m^2). In areas with low sand content, two nodes were opened related to the altitude, with larger infestations of *A. tenella* were accounting in areas with altitude above 868 m, however this occurred in only three locations compared to 68 locations where the incidence

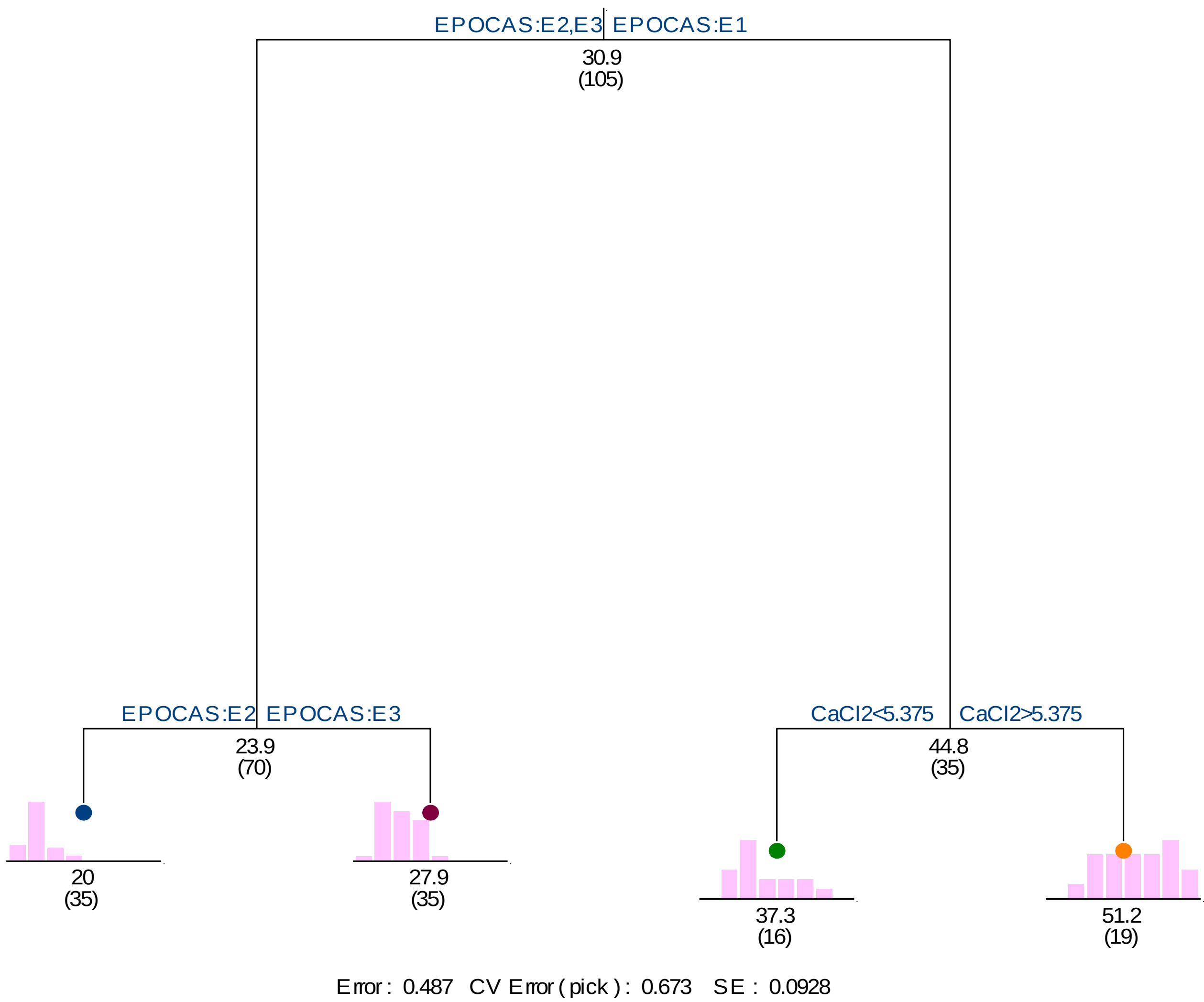

Figure 1. Factors related to the total occurrence of invasive species in the Southwest of Goiás, where: E1= survey before the pre-planting desiccation; E2: survey before the post-emergence in yield; E3: survey before the post-emergence in off-season; and $CaCl_2$: soil pH in $CaCl_2$. Database for analysis: number of individuals.

of this species remained very low (average of 0.56 plants per 5 m^2).

In most clayey areas, two terminal nodes were opened according to counting periods. Surveys conducted at period before pre-planting desiccation show greater infestations of *A. tenella* (average of 13.20 plants per 5 m^2) compared to periods related to harvest and off-season periods (average of 3.94 plants per 5 m^2). Clayey soils in sites with milder temperatures (higher altitudes) seem to favor the occurrence of this species, being clearer at the period before the pre-planting desiccation of main crop. According to Canossa et al. (2010), this species is herbaceous plant, highly branched, tending to form an intense coverage on soil. This species spreads by rooting from nodes in contact with soil.

Regarding the factors related to the occurrence of *Chamaesyce hirta*, tree containing three terminal nodes explained 34% of the total variability of data occurrence (Figure 4). The most important factor was the altitude, with greater *C. hirta* infestation in areas with lower altitude of 543 m (average of 13.70 plants per 5 m^2) compared to areas with higher altitude than this value (average of 2.30 plants per 5 m^2). Regarding the higher altitude areas, the amount of straw in soil was associated with the occurrence of this species, with local biomass with straw on soil surface higher than 1.95 t ha^{-1}(average of 3.97 plants per 5 m^2) being higher than am locations above 1,95 t ha^{-1} (average of 1.35 plants per 5 m^2). Data show *C. hirta* “preference” for sites with warmer temperatures (low altitude) and greater amount of straw on soil.

For *Euphorbia heterophylla*, the tree containing three terminal nodes explained 71% of the total variability of data occurrence (Figure 5). The most important factor

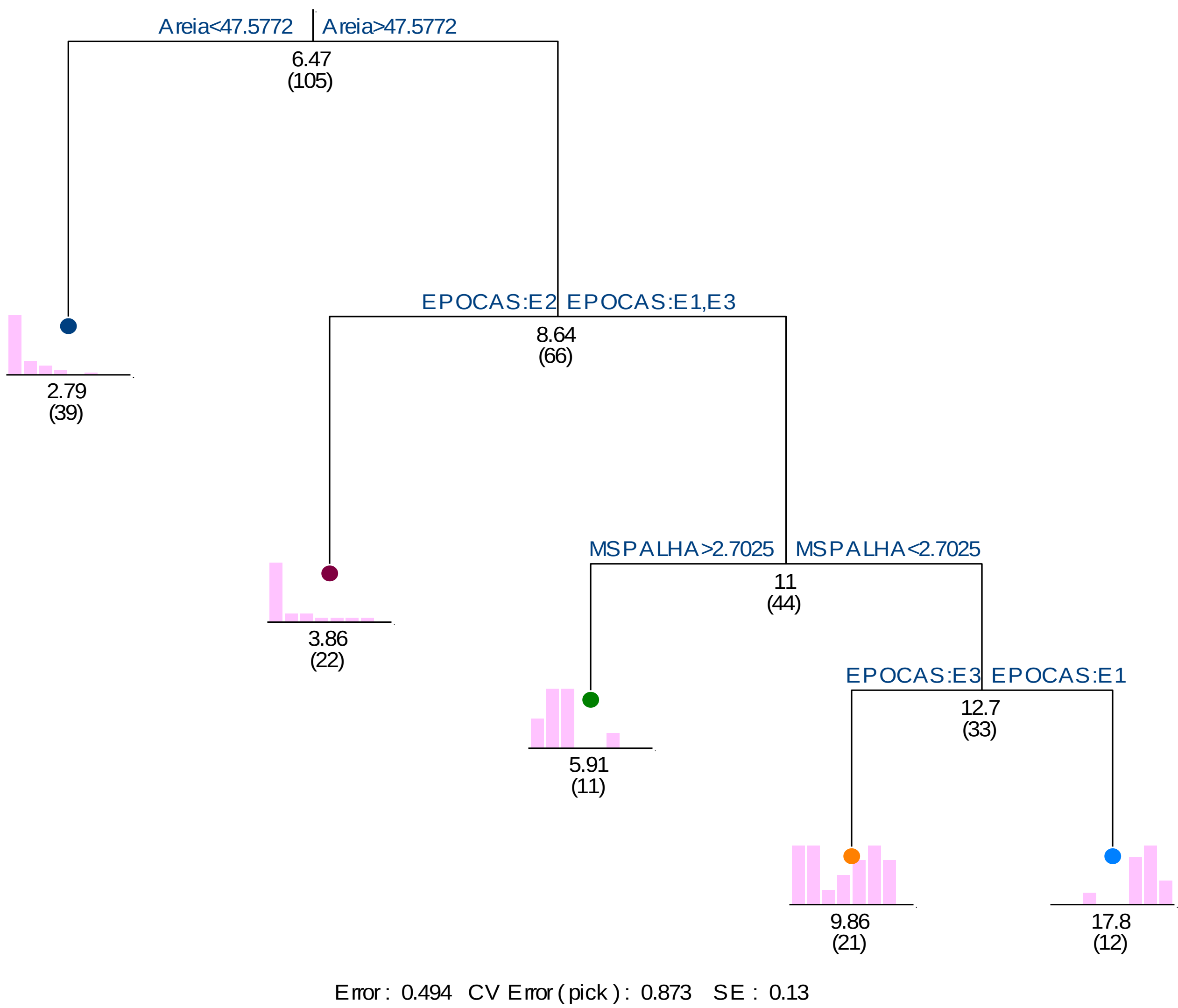

Figure 2. Factors associated to the occurrence of *Cenchrus echinatus* in the Southwest of Goiás, where: Sand: sand content in soil in %; E1: survey before pre-planting desiccation; E2: survey before post-emergence in yield; E3: survey before post-emergence in off-season; and MSPALHA: amount of dry straw biomass on soil surface in ha^{-1}. Database for analysis: number of individuals.

was the soil sand content, where there was a formation of two nodes, one indicating higher *E. heterophylla* infestation in areas with sand content higher than 71.7% (average of 2.96 plants per 5 m^2) compared to areas with sand content lower than 71.7% average of 0.26 plants per 5 m^2).

Two nodes were opened in areas with sand content exceeding 71.7%, and on conventional soybean cultivation, *E. heterophylla* incidence was higher (average of 5.83 plants per 5 m^2) than in the areas that adopt resistant cultivars to glyphosate (average of 0.67 plants per 5 m^2). These data indicate that sandy soils associated to conventional soybean cultivars facilitate the spread of *E. heterophylla* plants. The high distribution of *E. heterophylla* biotypes resistant to ALS-inhibiting herbicides used for weed control in conventional soybean crops may explain this result. According to Vargas et al. (2013), the adoption of genetically modified soybean for resistance to glyphosate, represented an alternative to control *E. heterophylla* biotypes resistant to acetolactato synthase inhibitors.

Regarding the occurrence of soybean (*Glycine max*) tree with three terminal nodes explained 71% of the total variability of data occurrence (Figure 6). The most important factor were evaluation periods, when there was the formation of two nodes, one indicating higher infestation of volunteer soybeans at off–season period (average of 8.11 plants per 5 m^2) compared to pre-planting desiccation periods and before post-emergence application in crop (no record of plant occurrence in these

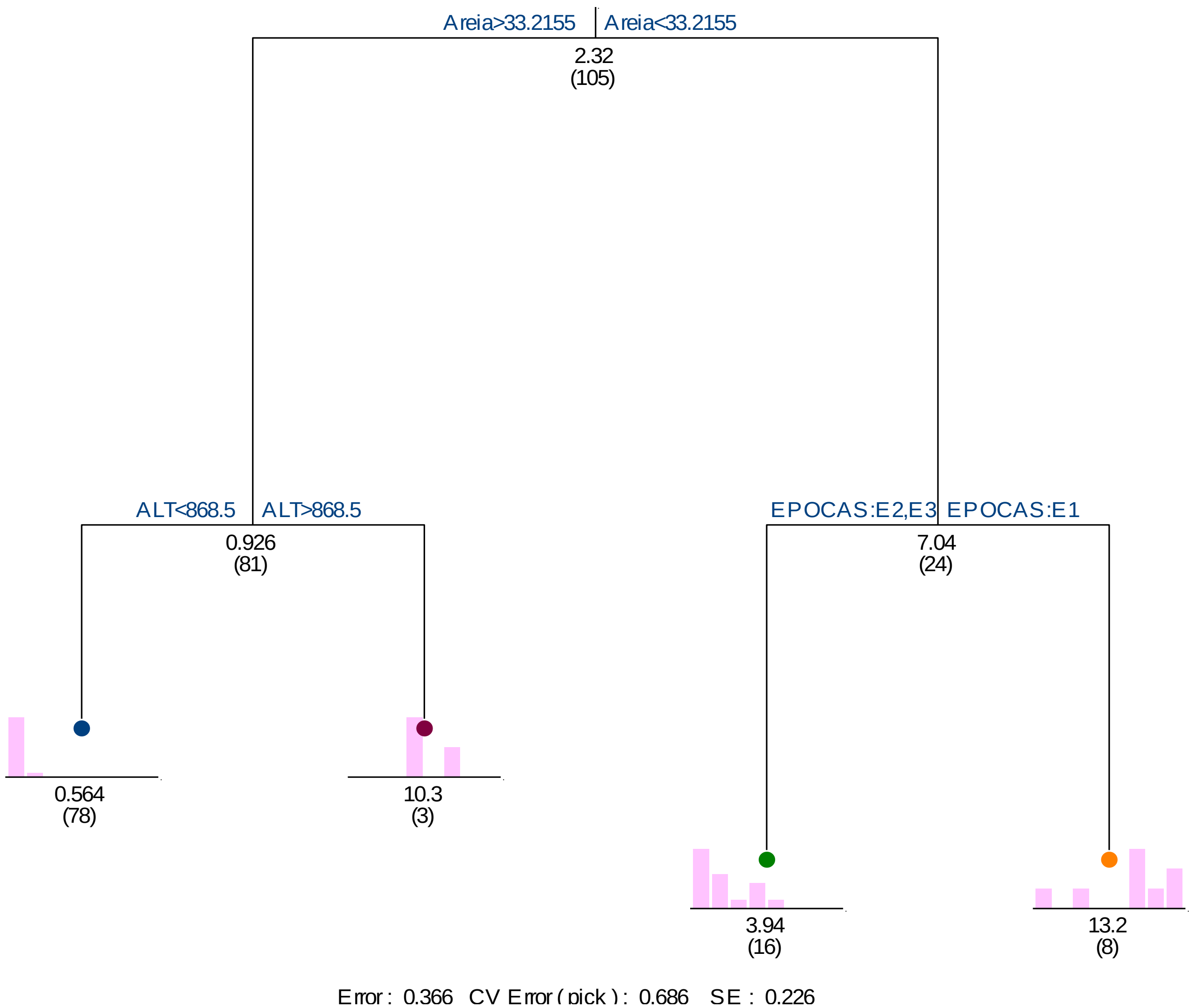

Figure 3. Factors associated to the occurrence of *Alternanthera tenella* in Southwest of Goiás, where: Sand: sand content in soil in%; E1 = survey before the pre-planting desiccation; E2: survey before the post-emergence in the crop; E3: survey before the post-emergence in the off-season; and ALT: altitude in meters. Database for analysis: number of individuals.

periods).

In off-season period, the areas with sand content higher than 24.6% showed a higher number of individuals (average of 9.00 plants per 5 m^2) compared to areas with sand content lower than 24.6% (average of 3.83 plants per 5 m^2). These data show that the soy infestation problem influences off -season crops, and problem is worse in areas with sandy soil. It is important to note that voluntary soybean plants can cause losses due to weed competition in subsequent crops (Dan et al., 2011).

The cultivation sites in sandy soils with poor dry biomass of straw surface contribute to *C. echinatus* infestation, especially prior desiccation of soybean pre-planting. Clayey soils and high altitudes favor the occurrence of *A. tenella*. Sites with low altitude and with higher dry matter content of the straw on soil surface favors the occurrence of *C. hirta.* Sandy soils associated to the cultivation of soybean conventional varieties in the first crop facilitate the occurrence of *E. heterophylla* plants. The volunteer soybean has influenced in cultivation of second crop especially in areas with high sand content.

We emphasize that the results obtained with this study, even in a broad geographical context, corroborate with studies carried out in other countries. According to a recent European study soil texture, soil pH and altitude were also among the most important factors determining weed species composition in conventional soybean fields (Pinke et al., 2016). In Europe and even on other continents weed species composition in different crops was most affected by edaphic factors (especially soil pH and soil texture) and altitude (Hanzlik and Gerowitt, 2016).

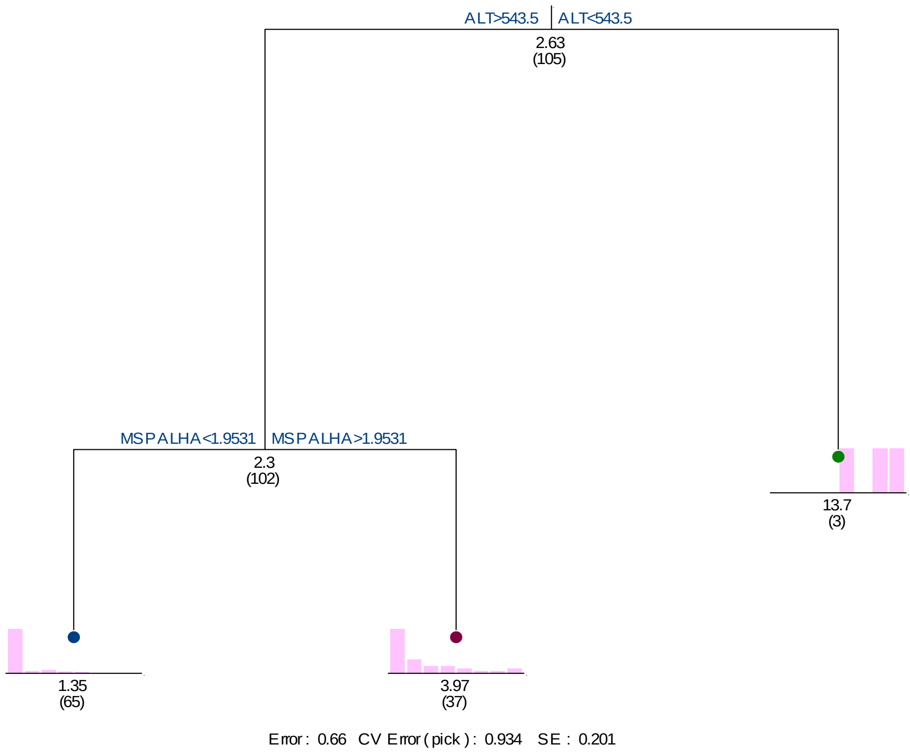

Figure 4. Factors associated to the occurrence of *Chamaesyce hirta* in the Southwest region of Goiás, where: ALT: altitude in meters; and MSPALHA: Amount of dry straw on soil surface in t ha^{-1}. Database for analysis: number of individuals.

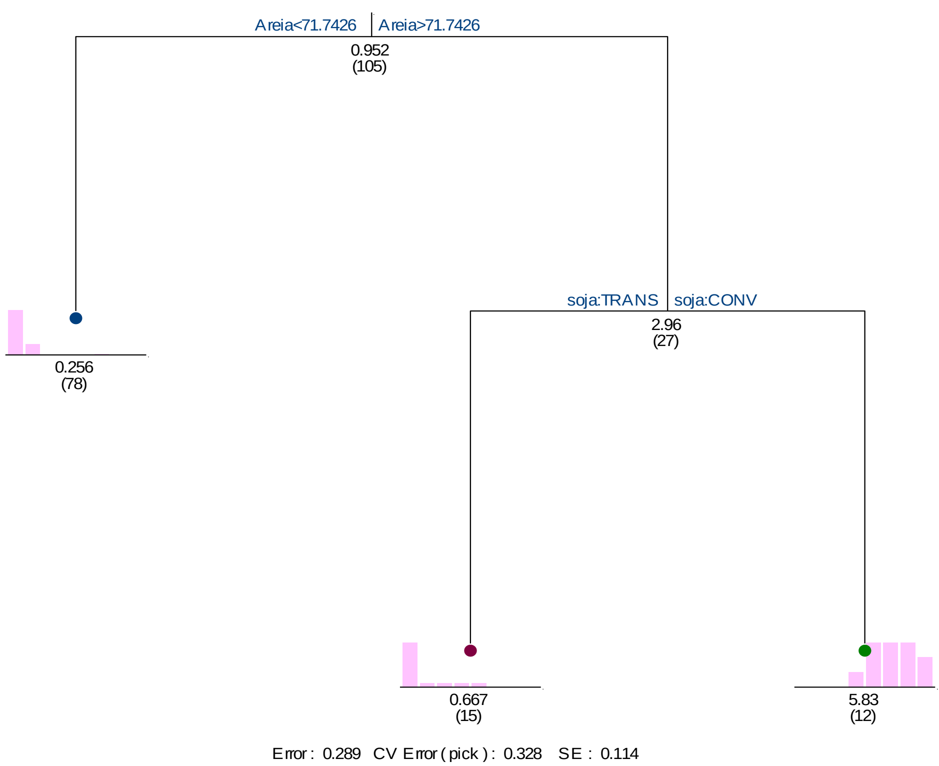

Figure 5. Factors associated to the occurrence of *Euphorbia heterophylla* in Southwest of Goiás, where: Sand: sand content in soil in%; Soybean: TRANS: RR soybean and soybeans: CONV: conventional soybean. Data base for analysis: number of individuals.

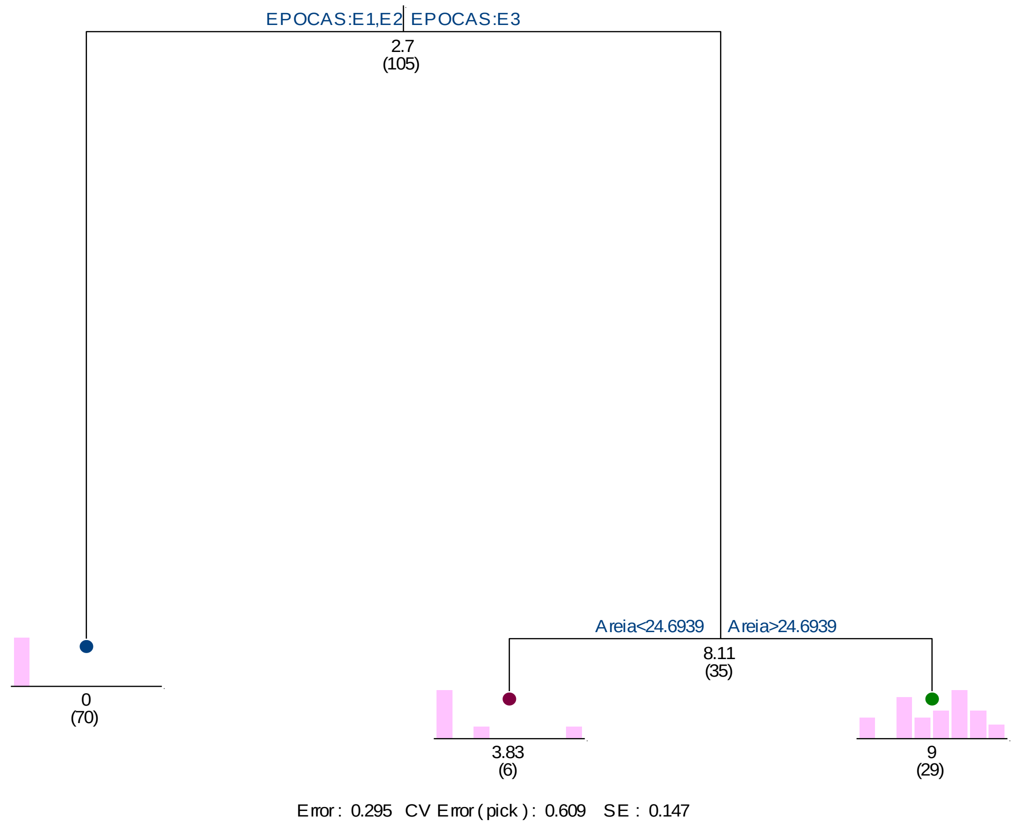

Figure 6. Factors that influenced the occurrence of *Glycine max* (soybean voluntary) in the Southwest of Goiás, where: E1: survey before the pre-planting desiccation; E2: survey before post-emergence in crop; E3: survey before post-emergence in the off - season; and Sand: sand content in soil in%. Database for analysis: number of individuals.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

Adegas FS, Oliveira MF, Vieira OV, Prete CEC, Gazziero DLP, Voll E (2010). Levantamento fitossociológico de plantas daninhas na cultura do girassol. Rev. Planta Daninha 28:705-716.

Alvarenga RC, Lara CWA, Cruz JC, Santana DP (2001). Plantas de cobertura de solo para sistema plantio direto. Inf. Agropecu. 22:25-36.

Balbinot JR AA, Veiga, M (2014). Densidade de plantas daninhas afetada por sistemas de manejo do solo e de adubação. Rev. Ciênc. Agrovet. 13:47-55.

Braun-Blanquet J (1979). Fitossociologia: bases para el estudio de las comunidades vegetales. 3th edn. Madri: Home Blume Ediciones 820 p.

Canossa RS, Oliveira JR RS, Constantin J, Rios FA, Cavalieri SD (2010). Efetividade de herbicidas no controle de *Alternanthera tenella.* Rev. Bras. Herb. 6:1-12.

Dan HA, Procópio SO, Barroso ALL, Dan LGM, Oliveira neto AM, Guerra, N (2011). Controle de plantas voluntárias de soja com herbicidas utilizados em milho. Rev. Bras. Ciênc. Agrár. 6:253-257.

De'Ath G, Fabricius KE (2000). Classification and regression trees: a powerful yet simple technique for the analysis of complex ecological data. Ecology 81:3178-3192.

De' Ath G (2002). Multivariate regression trees: a new technique for modeling species-environment relationships. Ecology 83:1105-1117.

Hanzlik K, Gerowitt B (2016). Methods to conduct and analyze weed surveys in arable farming. A review. Agron. Sustain. Dev. 36:11.

Jordan DL, York AC, Griffin JL, Clay P, Vidrine PR, Reynolds DB (1997). Influence of application variables on efficacy of glyphosate. Weed Technol. 11:354-362

Kapusta G, Krausz RF, Khan M, Matthews JL (1994). Effect of nicosulfuron rate, adjuvant, and weed size on annual weed control in corn (*Zea mays*). Weed Technol. 8:696-702.

Kissmann KG (1997). Plantas infestantes e nocivas. São Paulo: Basf Publications 824 p.

Lich JM, Renner KA, Penner D (1997) Interaction of glyphosate with post emergence soybeans (*Glycine max* L.) herbicides. Weed Sci. 45:12-21.

Mccune BJ, Mefford MJ (2011). PC-ORD. Multivariate Analysis of. Ecological Data. Version 6.0 Oregon: MJM.

Pinke G, Blazsek K, Magyar L, Nagy K, Karácsony P, Czúcz B & Botta-Dukát Z (2016). Weed species composition of conventional soyabean crops in Hungary is determined by environmental, cultural, weed management and site variables. Weed Res. 56:470-481.

Procópio SO, Menezes CCE, Betta L, Betta M (2007). Utilização de chlorimuron-ethyl e imazethapyr na cultura da soja Roundup Ready®. Rev. Planta Daninha 25:365-373.

Resende WG (1995). Efeito da época de semeadura de três leguminosas e três gramíneas forrageiras de inverno para produção de matéria seca e avaliação da cobertura morta em sistema de plantio direto. Monografia. Uberlândia, MG: Universidade Federal de Minas Gerais 40 p.

Salton JC, Kichel NA (1998). Milheto, uma alternativa para cobertura do solo e alimentação animal. Revista do Plantio Direto 45:41-43.

Santos HG, Carvalho Júnior W, Dart RO, Áglio MLD, Souza JS, Pares JG, Fontana A, Martins ALS, Oliveira AP (2011). O novo mapa de solos do Brasil. Documentos/Embrapa Solos-130, p. 67.

Shaner DL (2000). The impact of glyphosate tolerant crops on the use of other herbicides and on resistance management. Pest Manage. Sci. 56:320-326.

Silva AA, Silva JF (2007). Tópicos em manejo de plantas daninhas. P. 17-61. Universidade Federal de Viçosa.

Swanton CJ, Clements DR, Derksen D (1993). Weed succession under conservation tillage: a hierarchical framework for research and management. Weed Technol. 7:286-297.

Vargas L, Nohatto MA, Agostinetto D, Bianchi MA, Paula JM, Polidoro E, Toledo RE (2013). Práticas de manejo e a resistência de *Euphorbia heterophylla* aos inibidores da ALS e tolerância ao glyphosate no Rio Grande do Sul. Rev. Planta Daninha 31:427-432.

Webster TM, Sosnoskie LM (2010). The loss of glyphosate efficacy: a changing weed spectrum in Georgia cotton. Weed Sci. 58:73-77.

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Full Length Research Paper

Characterization of production system and breeding practices of sheep producers in Doyogena district, Southern Ethiopia

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An exploratory survey was undertaken in Doyogena district of Southern Nation Nationalities Peoples region of Ethiopia to understand the sheep production system, the breeding practices, selection criteria and sheep production constraints in order to develop a sheep breeding strategy. Data were collected from 107 households using semi-structured questionnaire and group discussion. Descriptive statistics and index were used to present the data. The agricultural production system of the area was *Ensete ventricosum* -crop-livestock production system. Crop production was found to contribute to most of the households' food and income followed by sheep and cattle production. The main sheep production objective was the sale of young and fattened sheep. The mean sheep holding was 4.02±2.58 to which most (43.5%) were breeding females. Only 47.2% of the respondents own breeding ram and 42.5% of them use controlled mating. Body size (index = 0.232) and appearance (index = 0.305) were the first selection criteria used for ewe and ram selection, respectively. Castration of rams and culling of unwanted sheep through sale, slaughter, and exchange was a common practice. Old age and poor physical condition were the first culling criteria for female and male sheep, respectively. Castration age ranges from 12 to 72 months when the ram have been used for breeding. Castrated animals were the first priority followed by young males to be sold in the flock when the family needs money. Feed shortage (index = 0.34), lack of input like credit service (index = 0.18), and diseases and parasites (index = 0.124) were the top three major sheep production bottlenecks in the district accounting for about 64.4% of the total weight. Finally, to fully utilize the potential of the breed and the area, production constraints need to be addressed along with genetic improvement and appropriate institutional setup.

Key words: Doyogena sheep, *Ensete ventricosum* -crop-livestock production system, fattening, selection criteria.

INTRODUCTION

Sheep production is among the most important agricultural activities in the highlands of Ethiopia where crop production is unreliable (Kocho, 2007; Gizaw et al., 2013a). Sheep provide farm households with cash income, meat, fiber, and manure. As compared to large ruminants such as cattle, sheep have shorter production cycles, faster growth rate, ease of management, and low capital investment (Gizaw et al., 2013a; Tadesse et al., 2015). In addition, they require small space and feed and therefore are efficient meat and milk producers for the smallholder in areas where there is no enough grazing land. These days, there is a general shift in livestock holding from cattle to small ruminant because of the consistently dwindling grazing land as a result of crop encroachment and degradation of communal grazing lands (Taye et al., 2010).

There is a large number of sheep in Ethiopia (26 million heads; (CSA, 2008)) and diverse genotype of sheep populations (Gizaw et al., 2007) maintained in different agro-ecological zones and ethnic groups. Most of the sheep (about 70%) are found in the highlands of the country maintained in the traditional husbandry system (Mengistu, 2006).

The traditional sheep production system in Ethiopia is constrained by feed scarcity, disease and parasite prevalence, lack of market information and technical capacity, and an absence of planned breeding programs and breeding policies (Kocho, 2007; Gizaw et al., 2013b). Because of this, production and productivity is very low below the biological potential of the animals. However, since these sheep have been evolved over centuries through diverse stress full tropical environments, they have developed different unique adaptive traits (Gizaw et al., 2013b). Therefore, an attempt to improve the productivity of animals needs to consider the prevailing conditions, specific purpose in the production system and their potential under varying management levels (Otte and Chilonda, 2003).

Doyogena sheep, named as Adilo sheep (Gizaw et al., 2007), is a breed of sheep reared in Doyogena district of the Southern Nations Nationalities and Peoples Regional (SNNPR) state. This breed of sheep is believed to be among the productive breeds of the country. However, like other breeds of the country (ESGPIP, 2008; Getachew et al., 2010a), the productivity level is below its genetic potential due to different production constraints and lack of appropriate breeding strategies developed for the breed in the production system. In an effort to develop a breeding strategy for a particular community and breed of sheep, understanding the indigenous breeding strategies and the resultant mode of livestock production is very important (Gizaw et al., 2013b). The objective of this research was to describe the production systems and objectives of sheep production in Doyogena district so as to develop sheep breeding strategy.

MATERIALS AND METHODS

Description of the study area

Survey data collected in Ancha, Serera and Awora peasant associations (PAs, the smallest administrative unit of Ethiopia) of Doyogena district was used for the study. Doyogena district is found in Kembata Tembaro Zone of SNNPR state. The district is situated at 258 km from Addis Ababa, the national capital, and 171 km from Hawassa, the regional capital. Doyogena district has an altitude range of 1900 to 2300 m above sea level (m asl), mean annual rainfall of 1200 to 1600 mm and the mean temperature varies from 10 to 16°C (Bureau of Agriculture (BoA) 2012, unpublished). There are two rainy seasons to which the main rainy season spans from June to September and a small shower falls from February to May. The major livestock species reared by the community include cattle, sheep and goat, equines, poultry, and the honey bee. The major crops grown in the district include *Ensete ventricosum*, Faba bean, wheat, barley, field pea and vegetables and others (Asmare et al., 2016).

Data collection and analysis

The survey district and PAs were purposively selected with an objective to develop a sheep breeding strategy in the study areas by Areka Agricultural Research center and International Center for Agriculture Research in the Dry Areas (ICARDA). Interviewee farmers who participated in the survey were randomly selected from those involved in sheep production.

Survey data was collected using questionnaire, focus group discussion, key informants interviews and visual observations. A semi-structured questionnaire was used to collect data on household characteristics, the major production system of the area, breeding and breeding methods of sheep, feeds and feeding management of sheep, selection, and culling criteria, and major sheep production constraints in the study area. Focus group discussion was held to supplement and verify data collected using the questionnaire survey. Checklist was prepared and used to guide the group discussion.

Data collected from the questionnaire survey were coded, entered, cleaned and analyzed using the Statistical Package for the Social Sciences (SPSS, 2008) computer statistical program. The descriptive statistics, frequency and cross tabulation procedures were used to analyze and present the data. Index was calculated for different parameters using the following general formula:

$$Index = \frac{\sum\left[\begin{array}{c}(N \times \text{Number of HH ranked 1st}) + (N-1 \times \text{Number of HH ranked 2nd}) + \cdots \\ (1 \times \text{Number of HH ranked Nth})] \text{ for each commodity or trait considered}\end{array}\right]}{\sum\left[\begin{array}{c}(N \times \text{Number of HH ranked 1st}) + (N-1 \times \text{Number of HH ranked 2nd}) + \cdots \\ (1 \times \text{Number of HH ranked Nth})] \text{ for all the commodities or traits considered}\end{array}\right]}$$

Where the numerator is for each commodity/trait under consideration, while the denominator is the sum of all the commodities/traits in the index calculation; HH: Household; N is a number of ranks.

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Table 1. Relative Household income contribution of crop and livestock in Doyogena district.

Item	Index	Rank
Crop	0.305	1
Sheep	0.248	2
Cattle	0.242	3
Vegetable	0.144	4
Apiculture	0.034	5
Trade	0.015	6
Goat	0.008	7
Poultry	0.003	8

RESULTS AND DISCUSSION

Production system and household characteristics

Most of the respondent farmers were males (89.6%) and have formal education of grade 4 and above (75.5%). About 18.9% of them were illiterate. The literacy rate obtained is higher than other areas reported in the literature (Kocho, 2007; Getachew, 2008; Gemiyu, 2009), indicating that there is better access to education than other areas. This can be taken as an opportunity to designing of breeding programs and other interventions in the area since education has an effect on technology transfer.

The mean age of household heads was 40.89±11.2 years which is in comparison with the results of Kocho (2007) and Gemiyu (2009) in Halaba district and of SNNPR. The average family size was 7.66±2.25 (range 3 to 12) of which 3.88±1.47 were male members and 3.78±1.5 were female members. This result is similar to other results in Alaba area (Gemiyu, 2009). The mean landholding was 0.776±0.46 hectares. There were farmers with no farming land. Most (69.2%, 0.53 ha) of the land was allocated for crop production; fallow[1] land occupied 0.132 ha (17%) and 0.102 ha (13.4%) was allocated for private grazing land. The mean landholding obtained agrees with previous report (Bassa, 2016).

The livelihood of most of the respondent farmers was based on agriculture alone (80.2%). Some farmers diversify their livelihood through trade (16%) and employment (3.8%) in addition to agriculture. The major (98.1%) farming activity was crop and livestock mixed agriculture. The major crops of the area which are produced by most of the farmers were *Enset* (96.2%), vegetable (91.5%), wheat (89.6%) and barley (69.8%). Other crops grown are faba bean (27.4%), field pea (10.4%), and maize (5.7%). The production system of the study area is *Enset*-crop-livestock production system. *E. ventricosum* is a staple food in the area. Every farmer plants *Enset* in the homestead. In southern Ethiopia, *Enset* based farming system is an indigenous and sustainable agricultural system (Mulualem and Walle, 2014). Crop production was found to contribute to most of the households' food and income followed by sheep and cattle production (Table 1).

Sheep production and objective

The mean sheep holding in Doyogena district found in the present study was 4.02±2.58 (Table 2). Most of the flock composition was comprised of breeding ewes (43.5%) followed by lambs (19.05%). The mean number of breeding rams in a household was 0.58±0.8. Castrated sheep were the least numerous in the flock. Flock composition is a reflection of the breeding objectives to which higher proportion of breeding females shows lamb production (Ibrahim, 1998; Taye et al., 2010). The mean flock size obtained in the current study was lower than reports obtained in other areas (Getachew et al., 2010b; Taye et al., 2011; Edea et al., 2012) which might be because of the lower landholding in the area (Kocho, 2007; Taye et al., 2010). The small flock size could be an obstacle to practice within flock selection which calls for necessitation of some form of collective action for the wider genetic pool of the communities flock for effective selection (Gizaw et al., 2013a).

Farmers in Doyogena district keep sheep to get cash income from the sale of young sheep (index = 0.295) followed by the sale of fattening sheep (index = 0.207) (Table 3). Saving and meat consumptions were the third and fourth objectives, respectively. This kind of sheep production objective is common in other parts of the country (Kocho, 2007; Getachew, 2008; Taye et al., 2010). Farmers in the study area prefer to produce Doyogena sheep because of their fast growth, attractive coat color, good physical appearance, adaptability, and twinning ability characteristics.

Sheep breeding and reproductive performances

Most of the respondent farmers (70%) do not determine the age at mating for both male and female sheep. Because there was no seasonal control of mating, there were lambings in every month of the year. However, there were peak lambings from October to December (Figure 1), indicating that most of the conception occurred during or following the small rains in May. A similar type of distribution of lambings throughout the year was reported for other breeds of sheep (ESGPIP, 2008; Taye et al., 2011).

The reproductive performance of Doyogena sheep is presented in Table 4. The mean age at first mating of Doyogena sheep obtained in the current study was 8.06 and 8.0 months for female and male sheep, respectively, which compares with the findings of Kocho (2007). The

[1]Fallow land – is land left from the cropping land for grazing of livestock for some time. It is not permanent grazing land.

Table 2. Flock size and demography of sheep in Doyogena districts.

Class of sheep	Mean	SD	Min	Max
Mean	4.02	2.58	1.00	19.00
Ewe (breeding female)	1.83	1.17	0.00	7.00
Ram (breeding male)	0.58	0.82	0.00	4.00
Young Female	0.55	0.94	0.00	4.00
Young Male	0.32	0.59	0.00	2.00
Lambs (suckling)	0.80	0.98	0.00	4.00
Castrate	0.12	0.43	0.00	3.00

Table 3. Sheep production objectives in Doyogena district as practiced by farmers.

Production objective	Index	Rank
Sale of young sheep	0.295	1
Sale of fattening sheep	0.207	2
Saving	0.159	3
Meat consumption	0.156	4
Manure	0.151	5
Skin	0.023	6
Prestige	0.009	7

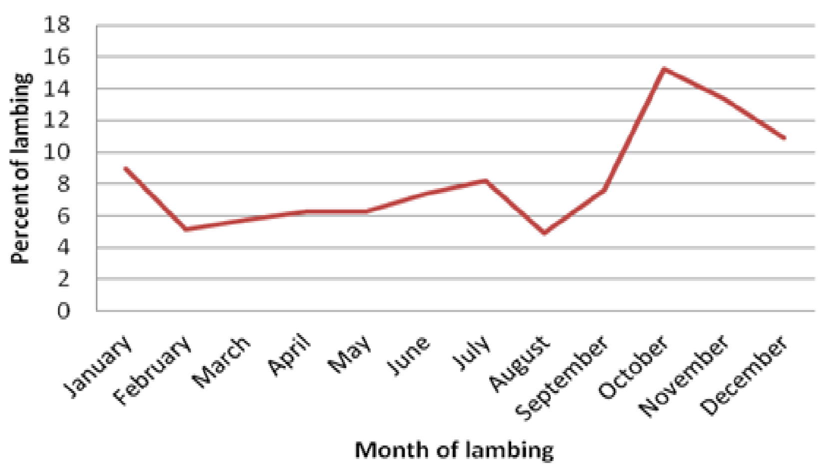

Figure 1. Lambing seasons of Doyogena sheep in Doyogena district.

mean age at first lambing (13.72 months) obtained is similar with Afar sheep (Getachew, 2008), lower than Washera sheep (Taye et al., 2011), and higher than Adilo sheep (Kocho, 2007). However, it is within the range of values reported for tropical sheep (Wilson, 1989).

The lambing interval (10.94 months) is longer than the values reported for other Ethiopian sheep breeds (Kocho, 2007; Getachew, 2008; Taye et al., 2011). With the lambing interval obtained it is not possible to give birth three times in two years which is said to be recommended for tropical sheep (ESGPIP, 2008). The longer lambing interval might be because, among a number of reasons, the breeding and herding methods (tethering method of herding) of the area. Breeding management is the primary responsible factor for lambing interval variation (Wilson, 1989).

Twinning rate obtained (1.45±0.45) is higher than the values reported for other sheep breeds in the country (Mukasa-Mugerwa et al., 2002; Taye et al., 2011) and even from tropical African sheep (Wilson, 1989).

Table 4. Reproductive performances of Doyogena sheep in Doyogena district.

Reproduction parameters	N	Mean	Std. Dev.	Range
Age at first mating of female sheep (month)	97	8.06	2.75	4.00-18.00
Age at first mating of male sheep (month)	100	8.00	2.61	5.00-18.00
Age at first lambing (month)	93	13.72	2.34	10.00-24.00
Lambing interval (month)	84	10.94	2.47	7.00-18.00
Twinning rate (head per ewe lambing)	101	1.45	0.45	1.00-3.00
Reproductive age of ewe (year)	97	8.31	3.00	3.00-17.00
Life time productivity (head)	96	10.05	3.43	4.00-20.00

Twinning rate, a combination of ovulation rate, fertility and embryo survival, is an important trait in small flock production to which sale of lambs is an objective (Taye et al., 2011), which makes use of the available resources efficiently. The higher twinning rate obtained might be because of the farmers' interest to consider the trait when selecting their breeding ewe, and the small flock size they own. Since genetic improvement in twinning rate is possible through selection (ESGPIP, 2008), selection of breeding rams towards twinning rate can bring a better and fast improvement.

Ram ownership and mating practice

About 47.2% of the respondent farmers own ram for breeding only (17%), fattening only (30.2%), breeding and fattening (27.4%) and breeding and prestige (1.8%), while the rest of the farmers get service from their neighbours (40.6%), and ram given from Areka Agricultural Research Center (13.2%). The mean ram ownership was 1.28±0.64. On average a ram serves for about 21.71±9.67 months in the flock. Some farmers keep up to four rams which were ultimately used for fattening. More than half (52.8%) of ram owners give special management for the ram like supplementation and separate housing from the flock. About 42.5% of the ram owners control mating by isolating the ram from the flock and mix them when needed (34.9%) and/or by castrating unwanted rams (6.6%). The rest of the farmers (57.5%) do not control mating because of the reasons including sheep graze together (40.55), lack of ram (3.8%), lack of awareness of the consequences of uncontrolled mating (9.4%), and herding problem (6.6%).

Most (61.3%) of the respondent farmers in the study area understand the effect of inbreeding as stunted growth (58.5%), poor health performance (8.4%), and abortion (4.7%). To control inbreeding, farmers change their ram and ewe (43.5%), separate their breeding ram from those related in the flock by tethering and castrating unwanted rams (8.5%). More than 56.6% of the respondent farmers control mating of related animals like the mating of ram with his mother, daughter, and sister while allowing mating their ram with other flocks and other rams with their flocks (72.6%). The result indicates that, when designing a breeding program for a community, the indigenous knowledge on breeding and mating methods and the herding system should be taken into consideration.

Breeding ewe and ram selection

Table 5 and Figure 2 present selection criteria of sheep in Doyogena area. Almost all (99.1%) respondents select their breeding ewes in which body size (index = 0.232) was the most important ewe selection trait followed by lamb growth (index = 0.175). During the group discussion, farmers indicated that horned ewes give more milk than polled animals supporting better lamb growth. Sheep with toggle are selected against the trait because they are not productive, in farmers view.

Among the respondents, 96.2% of them select their breeding ram from their own flock (71.7%), neighbors flock (46.2%) and purchase from the market (42.5%). Appearance (index = 0.305) and color (index = 0.254) of the ram accounted for more than half of the selection weight used as selection criteria. Likewise, Getachew et al. (2010b) reported that appearance of ram is an important trait for Menz and Afar sheep ram selection. Therefore, these qualitative traits also need to be given special attention when making selection decisions.

Castration practice

Most (84%) of the respondent farmers practice castration of rams for the sake of controlling unwanted mating (43.4%), fattening (77.4%), and improve temperament (39.6%). Similar reason for castration of sheep is reported in the literature (Getachew et al., 2010b). Some (36.8%) of the farmers castrate only during the dry season because they believe that the air condition is conducive than the wet season, and others (35.8%) castrate their rams during the wet season. Only a few practice castration regardless of the season. Castration was done using burdizzo (31.4%) or traditional method of castration using a stone and wood (32.6%), while 36% of

Table 5. Ewe and ram selection criteria as practiced by the sheep producers.

Characteristics	Ewe selection		Characteristics	Ram selection	
	Index	Rank		Index	Rank
Body size	0.232	1	Appearance	0.305	1
Lamb growth	0.175	2	Colour	0.254	2
Colour	0.144	3	Horn	0.133	3
Twinning ability	0.123	4	Character (Temperament)	0.057	5
Mothering ability	0.099	5	Growth	0.132	4
Lamb survival	0.092	6	Libido	0.039	6
Lambing frequency	0.077	7	Age at first maturity	0.039	6
Age at first maturity	0.036	8	Pedigree	0.030	7
Milk yield	0.015	9	Adaptability	0.007	8
Horned	0.008	10	Tail length	0.004	9

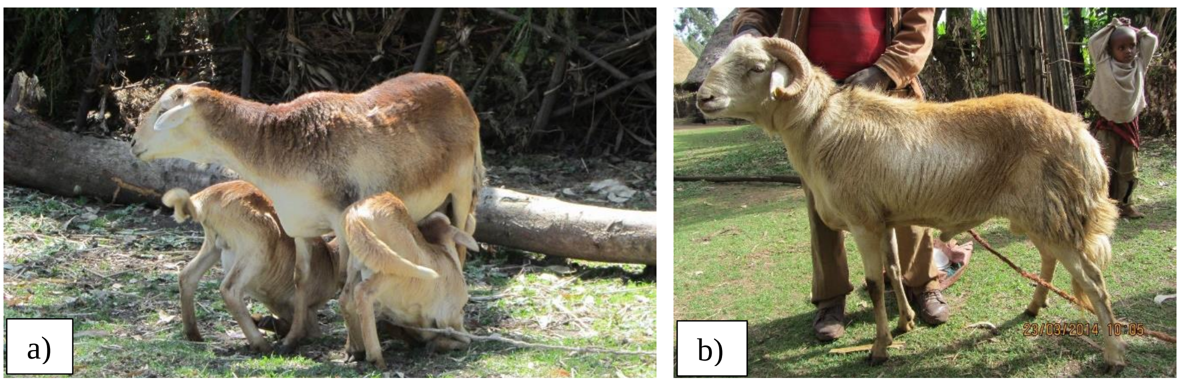

Figure 2. Preferred type of: (a) Ewe with her suckling twin lambs; (b) Breeding ram (Photo courtesy: Mengistie Taye).

the farmers use both methods, as available. The reason farmers use local methods of castration is because they do not have access to burdizzo castration (31.1%), ram response is better (9.4%), and because of tradition (7.5%).

Castration age differs depending on whether the ram has been used for breeding or not. The mean age of castration if the ram was used for breeding was after 28.68±11.15 months and if the ram was not used for breeding, it was at 12.09±4.10 months of age. Ram lambs could be castrated from 4 to 24 months of age when they are not selected for breeding. Some farmers castrate their young male sheep at an early age to control breeding and improve temperament while others tend to wait until the sheep gets matured for better body development and fattening. If the ram was used for breeding, castration age ranges from 12 to 72 months.

Sheep fattening

Sheep fattening is a common practice in the study area that 92.5% of the respondent farmers fatten sheep usually for market (77.4%), and for market and home consumption (13.4%). They fatten sheep by providing concentrate feed (79.2%), restricting movement (43.4%), and simply keeping the sheep for a long time (12.3%). About 56.6% of the sheep fattening farmers fatten from their own flock while 54.7 and 40.6% of them use animals purchased from the market and culled animals, respectively. Among the respondent farmers, 34.9% of them fatten in the dry season, 17.9% in the wet season and 28.3% of them during any time of the year as per the availability of feed and fattening animals. Sheep fatteners prefer to fatten sheep with light yellow and red coat colour (56.60%), castrates (13.21%), sheep with big horn (17%), mature (15%), large and well framed (60.38%), and long tailed (11.32%).

Farmers on average fatten 1.89±0.80 sheep in about 1.81±0.71 rounds per year. Duration of fattening was from two months to as long as 30 months with a mean of 9.65±5.96 months. Farmers prefer to fatten castrates (index = 0.384) with an age ranging from 12 to 60 months followed by intact males (index = 0.342). The mean age of fattening animals obtained was 29.22±10.09, 21.04±10.84 and 40.79±22.97 months for castrates,

Table 6. The culling reason for female and male sheep in Doyogena district.

Reason	Female sheep		Male sheep	
	Index	Rank	Index	Rank
Old age	0.187	1	0.162	4
Poor physical condition	0.167	2	0.210	1
Stunted growth	0.151	3	0.192	3
Sterility	0.121	4	0.028	7
Poor mothering ability	0.120	5	-	-
Disease	0.095	6	0.096	5
Low milk yield	0.093	7	-	-
Bad colour	0.064	8	0.207	2
Poor libido	-	-	0.084	6

Table 7. Priority of class of sheep for sale.

Class of sheep	Index	Rank
Castrate	0.190	1
Young male	0.187	2
Male lamb	0.182	3
Old ewe	0.155	4
Female lamb	0.134	5
Young Female	0.099	6
Ram	0.028	7
Ewe	0.024	8

males and female animals, respectively.

Culling practice

Most (90.6%) of respondent farmers practice culling of both ewes and rams using different criteria (Table 6). Farmers cull unwanted sheep through sale (88.7%), slaughter (36.8%) and exchange with other farmers (2.8%). Culling can be during the dry season (28.3%), wet season (26.4) and any time especially during holidays (34.0%). Old age, poor physical condition, and stunted growth were the first three culling reasons used for female sheep with an index of 0.187, 0.167 and 0.151, respectively (Table 6). For male sheep, poor physical condition (0.21), unwanted color (0.207) and stunted growth were the first three culling criteria used. More than half of the farmers add value to culled animals before selling them. Farmers castrate (index = 0.338) and/or fatten (index = 0.429) male sheep before selling, whereas they fatten (index = 0.575) female sheep before selling.

Sheep marketing

Farmers in Doyogena district sell sheep any time in the year when they need cash. However, sheep fattening farmers fatten and sell during holidays. Castrates (index = 0.19) were the first to be sold followed by young male (index = 0.187) and un-weaned male lambs (index = 0.182) in the flock (Table 7). Breeding ewes and breeding rams were the last choices for sale. Farmers do not want to sell breeding animals unless they are forced to do so.

Doyogena sheep, named as Adilo, has a premium market in Addis Abeba and other nearby markets. Medium and large traders collect fattened male animals to present at Addis Ababa and Shashemene markets during holidays (Kocho, 2007). The mean marketing age for male sheep was 6.11±2.72 months (1 to 12 months) and 6.87±2.55 months (2 to 18 months) for female sheep. Sale of sheep at an early age is common in other areas too (Kocho, 2007; Taye et al., 2010). This, the sale of young animals, has a negative effect on flock productivity that fast growing and good looking lambs could be removed out from the flock before reaching breeding age and replacing themselves (Taye et al., 2010), and therefore drains the genetic pool of the flock. However, the practice can be taken as an efficient method of removing less productive and unselected animals out of the system, if properly managed. Therefore, care should be taken to retain productive animals while removing those with unwanted traits.

Feed and water resources for sheep

Crop aftermath, private grazing land and *Amicho* (*E. ventricosum*) were the first three feed resources for sheep in the dry season with index of 0.194, 0.180 and 0.171, respectively, while private grazing (0.286), improved forage (0.193), and *Amicho* (0.166) were the most important feed resources in the wet season (Table 8). Farmers stated that feed shortage is a critical problem for sheep because of small landholding to allocate for private grazing and lack of communal grazing land, to which detail analysis is required on this aspect.

About 88.7% of sheep holders supplement *Amicho* and purchased concentrate to their sheep during different

Table 8. Wet and dry season feed resources of sheep in Doyogena district.

Feed resources	Dry season		Wet season	
	Index	Rank	Index	Rank
Crop aftermath	0.194	1	0.006	8
Private grazing	0.180	2	0.286	1
Amicho[1]	0.171	3	0.166	3
Concentrate	0.152	4	0.114	5
Communal grazing land	0.119	5	0.159	4
Crop residue	0.111	6	0.041	6
Improved feed	0.062	7	0.193	2
Hay	0.011	8	0.030	7

[1]Enset, Ensete ventricosum

Table 9. Priority of classes of sheep for feed supplementation.

Class	Index	Rank
Suckling ewes	0.319	1
Castrate	0.277	2
Lambs	0.137	3
Pregnant ewes	0.118	4
Breeding ram	0.077	5
Breeding ewes	0.072	6

times of the year: 62.3% supplement at all times of the year while 23.6% only during the dry season and 2.8% only during the wet season. Suckling ewes were the first classes of sheep in the flock to get supplement followed by castrates and lambs (Table 9). 40.6% of the respondent farmers give salt to their sheep at different times of the year with and/or without feed. Spring water (38.7%), stream (34%) and tape water (34.9%) were important sources of water for sheep both in the wet and dry seasons.

Herding of sheep

Most of the farmers herd their sheep with other livestock (63.2%), while 36.7% of them herd separately. About 61.3% of the farmers mix their sheep with other sheep flocks, because they use communal grazing land (50.0%), have labor shortage (7.6%) and during watering time (6.6%). For those mixing their flocks, on average 6.68 (2 to 30) households flocks mix together during grazing time.

Most of the respondents tether their sheep (90.6%) in the wet season to avoid crop damage while they freed them (67.9%) to roam around during the dry season. The use of tethering has an implication on the performances of the flock. While tethering is a means to control breeding allowing selected males to mate with female sheep coming to heat, when breeding is uncontrolled and when there is no follow-up, ewes might not be mated as they come to heat and this elongates lambing interval and in turn overall productivity. Therefore, the method of herding should be considered in the development of a breeding strategy.

Housing of sheep

All the farmers in the study area house their sheep to prevent them from theft, wild animals and environmental calamities in most (82.8%) of the cases with shelter constructed inside the main house. Only 10.3% construct separate house for their sheep and 6.8% of them house their sheep with open barn. About 78.3 and 55.7% of the farmers shelter lambs with adult sheep and sheep with other livestock, respectively. The practice is similar to other findings in the country (Taye et al., 2010; Mekuriaw et al., 2012).

Disease and disease control

The major diseases and parasites of sheep in the study area are presented in Table 10. There was less disease load in the area which is reflected in the low number of death of sheep during the year (only 1 to 3 farmers have lost their sheep due to disease). The major diseases of the area were respiratory diseases which usually cause morbidity. Farmers use different local treatments using usually ginger, garlic, and tobacco leaf. More investigation is however needed as some of the parasites, for example, may cause a substantial economic loss in terms of weight loss.

Farmers in the study area reported that they have access to vaccination (35.8%), diagnosis service (23.6%) and treatment (63.2%) when their sheep get sick from the government health clinic.

Slaughtering of sheep

About 91.5% of the farmers slaughter sheep for home

Table 10. Major diseases of sheep in Doyogena district (the common name is based on the symptoms seen).

Local name	Common name	Symptom	Local treatment
Elamosso	Pink eye disease	Swelling of orbit of eye, eye discharge, loss of vision, reddening and whitening of eye	Washing with water, treat with eye ointment
Samibicho	Respiratory syndrome	Coughing, diarrhea, loss of appetite, weight loss	Drenching garlic, ginger, *Tenadam*, *Emboy*
Gansho	Pneumonia	Coughing, Mucus discharge, Sneezing	Garlic, ginger, lemon, Tobacco

Table 11. Sheep production constraint in Doyogena district.

Constraint	Index	Rank
Feed shortage	0.340	1
Lack of input	0.180	2
Disease and parasite	0.124	3
Extension service	0.105	4
Land shortage	0.068	5
Water shortage	0.066	6
Labour shortage	0.065	7
Market problem	0.037	8
Genotype	0.015	9

consumption during festivals (86.8%), during occasions in the family like a wedding, births, circumcision, and funeral ceremony (83.0%) and whenever sheep for slaughter is available (2.8%). Farmers slaughter intact males (61.1%), females (4.5%), castrate (10.4%) and all types (18.9%). The mean age of sheep used for slaughter was 10.16 (4-36) months for males, 10.14 (4 to 24) months for females and 34.5 (24 to 48) months for castrates.

Sheep production constraint

Like other sheep producing areas of the country (Taye et al., 2010; Hailemariam et al., 2013), sheep production in Doyogena district has production constraints (Table 11). Feed shortage (index = 0.34), lack of input like credit service (index = 0.18), and disease and parasite (index = 0.124) were the three major sheep production bottlenecks in the district accounting for about 64.4% of the total weight. Unlike other areas (Getachew, 2008), genotype is not a problem. This might be partly because of lack of knowledge of the farmers about the availability of other better-producing breeds and the fact that their animals could be improved as there exists within breed variability.

CONCLUSION AND RECOMMENDATION

Sheep production is an integral component of the *E. ventricosum*-Crop-Livestock mixed production system of the area. Sheep are an important livestock species for the area. There is an established practice of selecting breeding rams and ewes by farmers. To help farmers in selecting ewes and rams and make a selection based on recorded data simplified methods of recording should be introduced. Farmers practice controlled breeding which needs to be encouraged and supported by introducing breeding control methods. The effect of tethering method of herding on the reproductive performances of sheep should be considered in developing the breeding strategy. Castration of rams and culling of unwanted sheep are common practices. Farmers in Doyogena district fatten sheep before selling. Feed shortage, lack of input, and disease and parasite are among the major sheep production bottlenecks in the district. To fully utilize the potential of the breed and the area, production constraints should be addressed along with genetic improvement and appropriate institutional setup.

Conflict of interests

The authors have not declared any conflict of interests.

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REFERENCES

Asmare B, Demeke S, Tolemariam T, Tegegne F, Wamatu J, and Rischkowsky B (2016). Determinants of the utilization of desho grass (Pennisetum pedicellatum) by farmers in Ethiopia. Trop. Grasslands-Forrajes Trop. 4(2):112-121.

Bassa Z (2016). Determinants of Improved Forages Adoption in Doyogena District of Kembata Tembaro Zone, in Southern Nations, Nationalities Regional State, Ethiopia. Glob. J. Sci. Front. Res. 16:3.

CSA (2008). Summary and statistical report of the 2007 population and housing census. In: G. o. E. Central Statistical Agency (ed.), Addis Ababa, Ethiopia.

Edea Z, Haile A, Tibbo M, Sharma A, Sölkner J, Wurzinger M (2012). Sheep production systems and breeding practices of smallholders in western and south-western Ethiopia: Implications for designing community-based breeding strategies. Livest. Res. Rural Dev. 24:7.

ESGPIP (2008). Sheep and Goat Production Hand book for Ethiopia. Brana Printing Press, Addis Ababa, Ethiopia.

Gemiyu D (2009). On-farm performance evaluation of indigenous sheep and goats in Alaba, southern Ethiopia. MSc thesis, Hawassa University, Awassa, Ethiopia.

Getachew T, Haile A, Tibbo M, Sharma A, Kifle A, Terefe E, Wurzinger M, Sölkner J (2010a). Morphological characters and body weight of Menz and Afar sheep within their production system. Ethiop. J. Anim. Prod. 9(1):99-115.

Getachew T, Haile A, Tibbo M, Sharma A, Sölkner J, Wurzinger M (2010b). Herd management and breeding practices of sheep owners in a mixed crop-livestock and a pastoral system of Ethiopia. Afr. J. Agric. Res. 5(8):685-691.

Getachew T (2008). Characterization of Menz and Afar indigenous sheep breeds of smallholders and pastoralists for designing community-based breeding strategies in Ethiopia. MSc thesis, Haramaya University, Ethiopia.

Gizaw S, Abegaz S, Rischkowsky B, Haile A, Mwai A, Dessie T (2013a). Review of sheep research and development projects in Ethiopia. Nairobi, Kenya: International Livestock Research Institute (ILRI). 60 pp.

Gizaw S, Getachew T, Edea Z, Mirkena T, Duguma G, Tibbo M, Rischkowsky B, Mwai O, Dessie T, Wurzinger M (2013b). Characterization of indigenous breeding strategies of the sheep farming communities of Ethiopia: A basis for designing community-based breeding programs ICARDA working paper., Aleppo, Syria. 47pp

Gizaw S, Van Arendonk JA, Komen H, Windig J, Hanotte O (2007). Population structure, genetic variation and morphological diversity in indigenous sheep of Ethiopia. Anim. Genet. 38(6):621-628.

Hailemariam F, Melesse A, Banerjee S (2013). Traditional sheep production and breeding practice in Gamogofa Zone, Southern Ethiopia. Int. J. Livest. Prod. 1(3):26-43.

Ibrahim H (1998). Small ruminant production techniques. ILRI (aka ILCA and ILRAD).

Kocho T (2007). Production and marketing systems of sheep and goats in Alaba, southern Ethiopia. MSc thesis, Hawassa University, Hawassa, Ethiopia.

Mekuriaw S, Mekuriaw Z, Taye M, Yitayew A, Assefa H, Haile A (2012). Traditional management system and farmers' perception on local sheep breeds (Washera and Farta) and their crosses in Amhara Region, Ethiopia. Livest. Res. Rural Dev. 24:11.

Mengistu A (2006). Country Pasture/Forage Resource Profiles. Ethiopia View Article PubMed/NCBI Google Scholar.

Mukasa-Mugerwa E, Anindo D, Sovani S, Lahlou-Kassi A, Tembely S, Rege J, Baker R (2002). Reproductive performance and productivity of Menz and Horro sheep lambing in the wet and dry seasons in the highlands of Ethiopia. Small Rumin. Res. 45(3):261-271.

Mulualem T, Walle T (2014). Farmers indigenous knowledge and assessment of enset (Ensete ventricosum Welw. Cheesman) cultivars for major insect pests in Ojojia water shade Kembata-tembaro zone, South Ethiopia. Sky J. Agric. Res. 3(6):112-119.

Otte J, Chilonda P (2003). Classification of cattle and small ruminant production systems in sub-Saharan Africa. Outlook Agric. 32(3):183-190.

SPSS (2008). Statistical Package for Social Science for Window, Version 16.0.

Tadesse E, Negesse T, Abebe G (2015). Sheep production and marketing system in southern Ethiopia: the case of Awassazuria district. Trop. Anim. Health Prot. 47(7):1417-1425.

Taye M, Abebe G, Lemma S, Gizaw S, Mekoya A, Tibbo M (2010). Traditional management systems and linear body measurements of Washera sheep in the western highlands of the Amhara National Regional State, Ethiopia. Livest. Res. Rural Dev. 22(9).

Taye M, Abebe G, Lemma S, Gizaw S, Mekoya A, Tibbo M (2011). Reproductive Performances and Survival of Washera Sheep under Traditional Management Systems at Yilmanadensa and Quarit Districts of the Amhara National Regional State, Ethiopia. J. Anim. Vet. Adv. 10(9):1158-1165.

Wilson R (1989). Reproductive performance of African indigenous small ruminants under various management systems: a review. Anim. Reprod. Sci. 20(4):265-286.

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Full Length Research Paper

Agronomic performance of hybrids and varieties of maize in function of nitrogen in coverage

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This study aims to compare the agronomic performance and the productivity of the corn hybrid AG 1051 and the Incaper Capixaba 203 variety in function of different nitrogen (N) doses in coverage. The experiment was held at the Federal Institute of Espírito Santo - Campus Santa Teresa. The design was of randomized blocks and the treatments were arranged in a split plot scheme, with four repetitions. The plots were represented by two corn genotypes and the subplots consisted of five N doses coverage: 0, 60, 120, 180 and 240 kg ha^{-1} N. After flowering, the plant height, stem diameter, the height of ear insert and the number of leaves per plant were evaluated. After harvest, the number of grains per spike, the 1000 grain and grain productivity were evaluated. All N dosages influenced all the features evaluated for both genotypes, which showed an increase with the increasing dose of the nutrient. The differences between the genetic materials to all the analyzed variables, except in grain productivity were found. The N dose estimated provides greater productivity for average grain (8785.98 kg ha^{-1}) for both genotypes 207.17 kg ha^{-1} of N.

Key words: Genetic material, levels of nitrogen, productivity, urea, *Zea mays*.

INTRODUCTION

Corn is a major cereal because of its various forms of use, ranging from animal feed till the industry. According to Conab (2016), 9th survey of crop, the Brazilian area designated for cultivation of the corn in the 2015 to 2016

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harvest was of 10.28 million hectares and the grain production was of 79,955,200,000 tons. The culture has a high production potential, however, the Brazilian average productivity is low (5,107 kg ha^{-1}) when compared with China and the United States (Conab, 2016).

Even though the productivity is dependent on the balance between the essential soil nutrients, nitrogen (N) is the most responsive nutrient in production of corn. According to Lourente et al. (2007), N is one of the minerals required in larger amounts in the cultivation of corn. This nutrient plays an important role in achieving high productivity, verifying wide range of recommendations, which vary from 50 to 150 kg ha^{-1} (Mendes et al., 2011).

Most studies involving nitrogen fertilization in corn is directed almost exclusively to evaluations with hybrid materials, neglecting the responsive capacity of varietal cultivars, which are still used by most farmers in the country. In addition, few studies relate the genetic potential to the nitrogen amount.

Fertilizer recommendations in Espírito Santo are based on Prezotti et al. (2007), which state that the level of N varies according to the corn productivity, indicating that corn crops with productivity between 3500 and 5500 kg ha^{-1} should receive 10 kg ha^{-1} of N at seeding and 60 kg ha^{-1} N in coverage. Crops with higher productivity than 5,500 kg ha^{-1} should receive 10 to 15 kg ha^{-1} N at seeding and 100 to 120 kg ha^{-1} N in coverage.

Another important fact noted in the recommendations of Prezotti et al. (2007) is that these authors do not consider the genetic potential as characteristics in their fertilizer recommendations for corn, being that the morphological and physiological changes in modern maize hybrids suggest changes in the dynamics of absorption of N by increasing the ability of the plant to absorb it during the grain filling (Silva et al., 2005).

According to Carvalho et al. (2011), the information about the absorption efficiency, associated with the genetic potential of cultivars and the optimal dose of N for each genetic material, can assist in the making of producers' decisions about the management and the choice of the crop cultivar to be used, in increasing the productivity and profitability of the same crop.

With this, the objective of this study was to evaluate the agronomic performance and productivity of the corn hybrid and a variety in function of different doses of N in coverage.

MATERIALS AND METHODS

The experiment was carried out in the field, from November 2014 to April 2015, in a soil classified as eutrophic ultisol (Embrapa, 2013) with sandy clay loam texture, located at the Federal Institute of Espírito Santo - Campus Santa Teresa, at 138 m of altitude and coordinates 19° 48'9 "S and 40° 40'32"O. The climate is Cwa type (subtropical dry winter) with an annual average temperature and precipitation of 18°C and 845.2 mm, respectively (Nascimento, 2013).

The soil had the following characteristics in the topsoil from 0 to 20 cm: pH (in H_2O) = 6.0; Al exchangeable ($cmol_c$ dm^{-3}) = 0.0; H+Al = 2.5 ($cmol_c$ dm^{-3}); Ca ($cmol_c$ dm^{-3}) = 2.5; Mg = ($cmol_c$ dm^{-3}) = 0.7; P Mehlich (mg dm^{-3}) = 8.0; P remaining (mg L^{-1}) = 28.0; K (mg dm^{-3}) = 110; S (mg dm^{-3}) = 9.0; organic matter (dag kg^{-1}) = 2.2; Fe (mg dm^{-3}) = 85; Zn (mg dm^{-3}) = 9.9; Cu (mg dm^{-3}) = 3.2; Mn (mg dm^{-3}) = 218; B (mg dm^{-3}) = 0.31; Na (mg dm^{-3}) = 40; V (%) = 58.2; CTC effective ($cmol_c$ dm^{-3}) = 3.5; CTC a pH 7.0 ($cmol_c$ dm^{-3}) = 6.0; sum of bases ($cmol_c$ dm^{-3}) = 3.5; saturation of Ca in CTC (%) = 41.8; saturation of Mg in CTC (%) = 11.7; saturation of K in CTC (%) = 4.7; clay (g kg^{-1}) = 300; silt (g kg^{-1}) = 118; sand (g kg^{-1}) = 582.

The design was in randomized blocks with treatments arranged in split plots, with four repetitions. The plots were represented by two genetic material, being one commercial hybrid (AG-1051), considered with high productivity, and one varietal (Capixaba 203), material developed by the Capixaba Institute of Research, Technical Assistance and Rural Extension (INCAP). Each subplot consisted of five N doses on coverage: 0, 60, 120, 180 and 240 kg ha^{-1} N. Each subplot composed of four rows of corn, 7 m long. The two central lines were considered useful, despising 1 m at each end.

The soil preparation was done by one plowing and two disking and the correction of the soil for sowing followed the recommendations of Prezotti et al. (2007), in function of the results of the chemical analysis from the soil, being employed 786 kg ha^{-1} dolomitic limestone (PRNT 90), 10 kg ha^{-1} N; 50 kg ha^{-1} P_2O_5 and 30 kg ha^{-1} K_2O.

Sowing was done manually in the groove line. Spacing of 0.9 m was used between rows and 10 seeds were distributed in each linear meter. It was made rough three days after emergence (DAE), remaining five plants per linear meter, in order to secure a final stand of 55,000 plants ha^{-1}, according to plant density recommendation suggested by seed suppliers.

Nitrogen fertilization of coverage in each treatment was parceled into four times, following the recommendation suggested by Prezotti et al. (2007), being that 30% of the total dose was applied to 15 (DAE), 30% at 30 DAE, 20% at 45 DAE and 20% at 60 DAE, using urea as a source of N. Applications of fertilizers were done manually after irrigations with homogeneous distribution in continuous bead to 10 cm from the plant. Irrigation was carried out in the morning by means of spraying and performed according to the crop needs in relation to the reference evapotranspiration, whilst maintaining the water content in soil at field capacity.

After flowering, 75 DAE, following the characteristics were evaluated in 15 plants within each useful subplot: (a) plant height (pH), measured from the ground level to the insertion of the last fully expanded leaf; (b) stem diameter (SD), measured with the aid of a digital caliper in the second internode stem from the ground; (c) spike insertion height (SIH), measured from the ground level to the insertion of the first tenon; (d) number of leaves per plant (NLP), obtained by counting the fully expanded leaves.

The harvest was done manually within the area of each subplot, picking up all the grain with straw. The threshing of the corn was performed with the manual thresher aid. Subsequently, evaluated: (e) number of grains per spike (NGS), multiplying the number of kernel rows by the number of kernels per row of each tenon; (f) mass of 1,000 grains (MMG), obtained by manual count of 400 grains, weighing and moisture correction to 13%, extrapolating the results for 1000 grains by simple rule of three; g) grain productivity (GP), determined by harvesting the corn, threshing and weighing of grain with higher moisture correction to 13% and extrapolating the results to kg ha^{-1}.

The data was subjected to analysis of variance. For the purposes of the amounts of N, variables were studied by polynomial regression analysis and for the differentiation of genotypes, the treatment averages were compared applying the Tukey test at 5% probability level. For the variables that regression showed quadratic effect, the first order derivative of the function to estimate its maximum point was used.

Table 1. Average values of plant height (AP), height of insertion of the first tenon (IEA), stem diameter (DC), number of leaves per plant (NFP), number of grains per tenon (NG), mass of 1000 grains (MMG) and grain productivity (GP) for hybrid and varietal corn.

Trat.	PH (cm)	SIH (cm)	SD (mm)	NLP	NGS	MMG (g)	GP (kg ha^{-1})
Hybrid	200.15[b]	128.36[b]	22.83[a]	11.17[b]	572.06[a]	258.37[b]	7,419.79[a]
Varietal	236.61[a]	138.26[a]	21.99[b]	12.16[a]	485.66[b]	342.75[a]	7,345.99[a]
CV (%)	1.14	4.14	1.94	7.03	7.34	6.64	6.92

The averages followed by the same letter in each column do not differ statistically from each other. Tukey's test was applied at the level of 5% probability.

RESULTS AND DISCUSSION

Differences were found ($P<0.05$) between genetic materials for all variables, except for grain productivity. Because of their higher rusticity, varietal material showed plants with larger insertion of the first tenon, higher number of leaves, heavier grains, smaller stem diameter, and fewer grains per tenon than the hybrid material as shown in Table 1.

According to Costa et al. (2012), higher plants often have more leaves and accumulate more nutrients, which are translocated to the grain in the grain filling period. Moreover, the higher plants are more prone to lodging occurrence. Fields et al. (2010) state that the greater the height of insertion of the spikes, the greater the chance of bedding plants, resulting in losses in productivity. Furthermore, smaller plants are more efficient in mechanical harvesting (Vilela et al., 2012).

In contrast, plants with thick stems are more resistant to overturning by wind, rain and soil compaction caused by the machine traffic and implementations during the management operations of culture and harvest of crops (Cruz et al., 2008).

The N doses influenced all the characteristics evaluated in both genetic materials. As regression analysis was being analyzed, linear effect increasing due to the increase of N doses in both corn genotypes studied was observed, for the variables: pH (Figure 1A), SIH (Figure 1B), and SD (Figure 1D), which showed similar behavior. When it comes to the number of leaves per plant, the hybrid showed linear increase with increasing doses of N. As for the varietal, quadratic behavior in function of N levels was observed (Figure 1C).

The increase in N rate increase brought the pH and SIH parameters, showing the direct effect of nitrogen on the vegetative functions of the plants. Similar results were obtained by Lange et al. (2014) who observed a significant linear increase in pH with increase in urea dosing in coverage. The SD followed the same principle, but the hybrids showed greater slope inclination when compared with the variety, indicating that this genetic material has greater capacity to synthesize nitrogen and deposit it in reserve tissues. The results obtained are in accordance with the Goes et al. (2013), which showed that higher doses of nitrogen in coverage generates an increase in the SD of the plants.

Regarding the NLP, nitrogen had greater influence on the corn variety, which expressed maximum yield at a dose of 222.14 kg ha^{-1} of N, producing an average of 13.45 leaves per plant. Plants with larger leaves tend to have higher photosynthetic rate and consequently greater production reserves, influencing directly on the crop yield. However, this result shows the lower N assimilation capacity of the corn variety, because when subjected to high doses of N shows an adverse effect on sheet formation, possibly as early shading, since the height of plants showed increase under the same conditions of N.

According to Figure 2A, there was a quadratic effect in function of the regression of N rates for the number of grains per spike in both materials. Figure 2B shows the weight of 1,000 grains, wherein the regression analysis showed linear effect for the hybrid and quadratic in the varietal, which showed maximum mass (373.59 g) obtained at a dose of 157.69 kg ha^{-1} of N.

The hybrid had higher average grain yield per spike (639.72) at a dose of 213.18 kg ha^{-1} N, however, the varietal showed the maximum production (520.36) when subjected to the dosage 161.03 kg ha^{-1} N.

These results show the morphological characteristics of genetic material, where the varietal corn, probably due to its greater hardiness, uses its reserves to produce larger size and mass grains, unlike hybrid corn, which has increased production of grains per spike but with smaller size and mass grains.

Sichocki et al. (2014) observed the same behavior mass of 1,000 grains of corn hybrids, which showed a steady increase in its mass with increasing nitrogen content coverage. However, the corn variety, despite its greater mass, found restrictions of absorption and utilization of nutrients, showing that doses above the maximum agronomic point become harmful, and can cause low economic return.

Figure 3 show that the average grain productivity showed a quadratic effect due to the N dose in coverage, with no difference between genotypes statistics.

The N rate estimated for the highest average grain yield (8,785.98 kg ha^{-1}) was of 207.17 kg ha^{-1} N. This result contradicts those obtained by Santos et al. (2013), Farinelli and Lemos (2010) and Goes et al. (2013) who obtained maximum grain yield with the culture of doses of

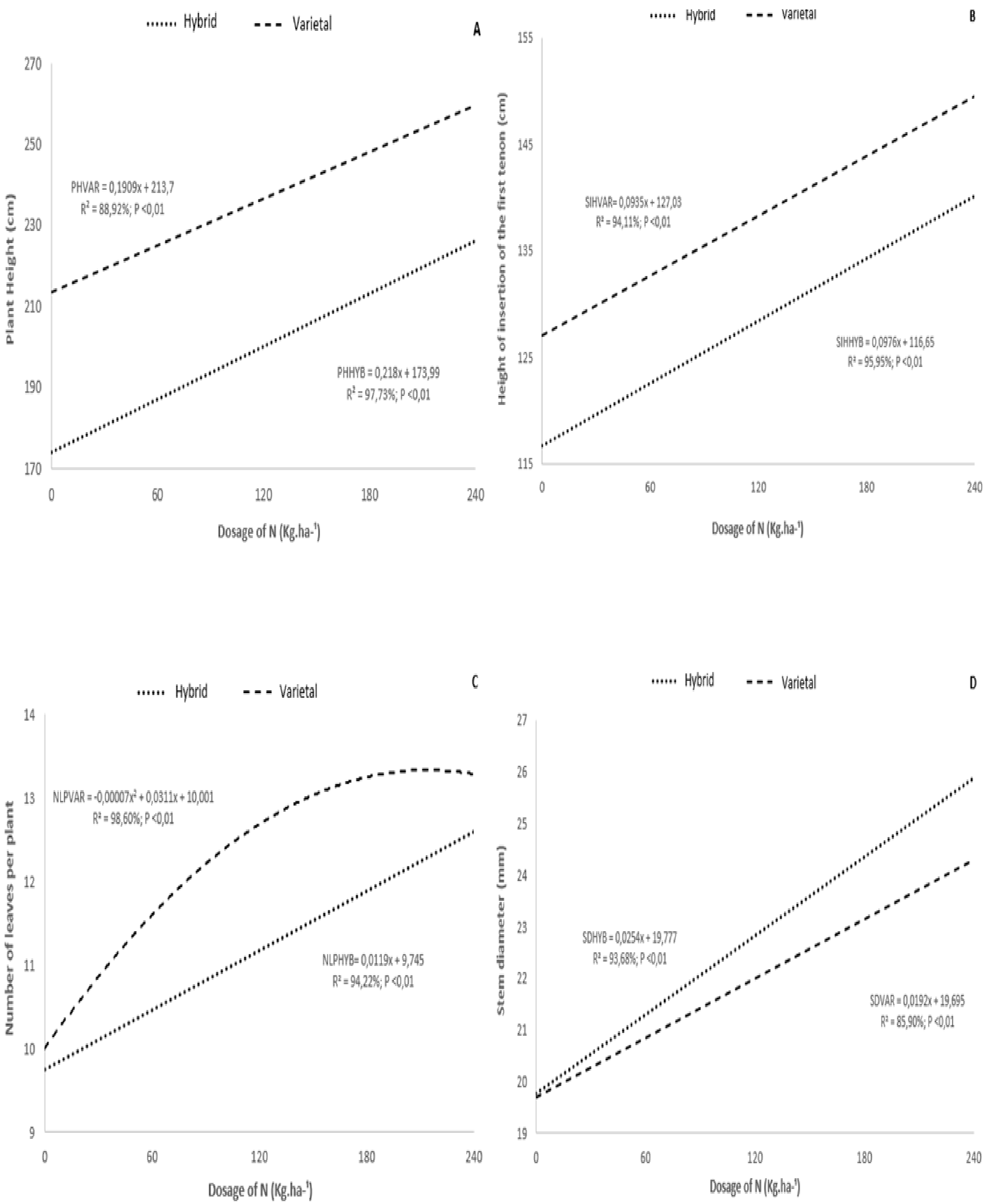

Figure 1. Plant height (A), height of insertion of the first tenon (B), number of leaves per plant (C), stem diameter (D) of each genetic material in function of the N dosage in coverage.

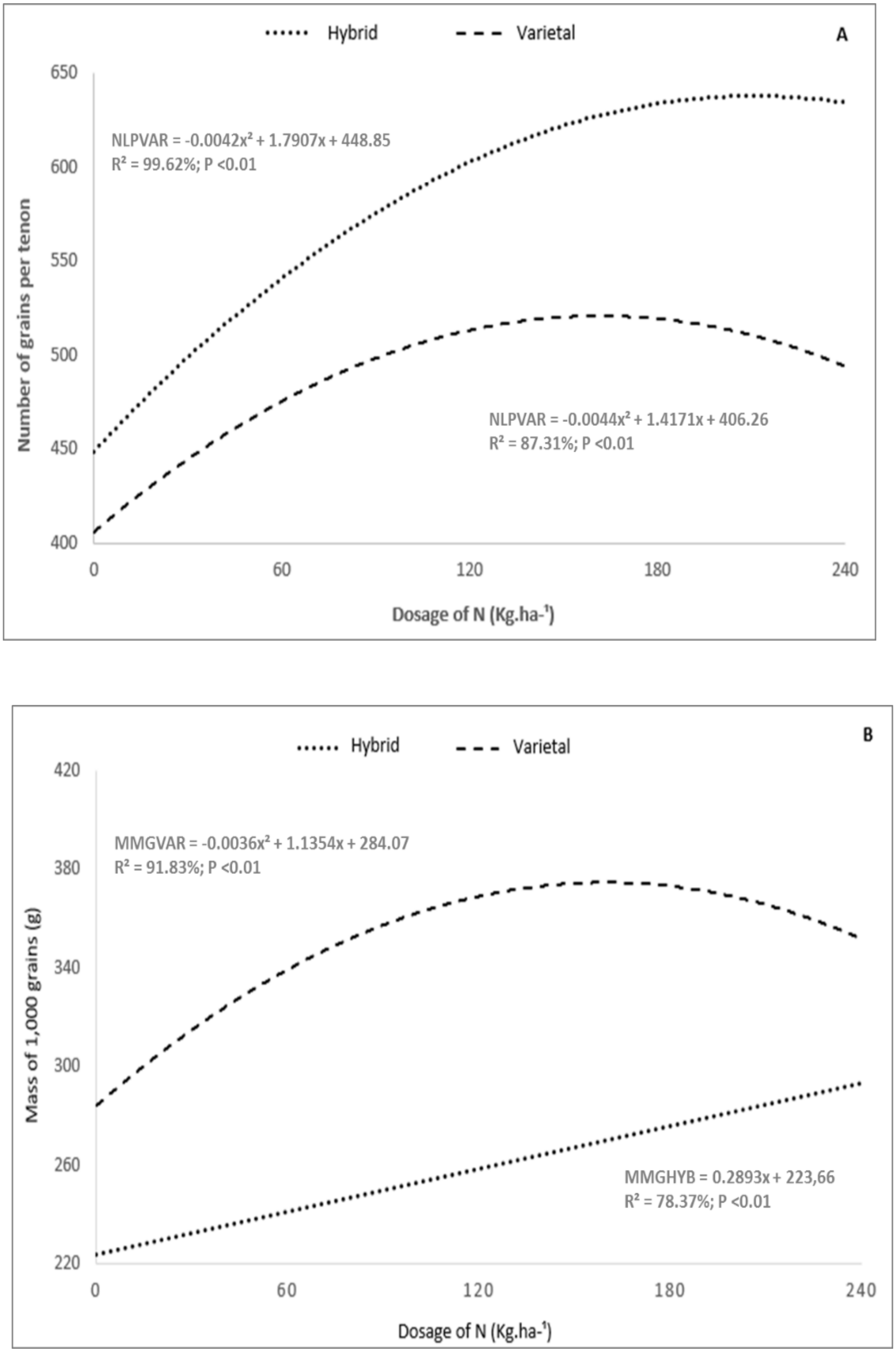

Figure 2. Number of grains per tenon (A) and mass of 1,000 grains (B) from each genetic material in function of the N dosage in coverage.

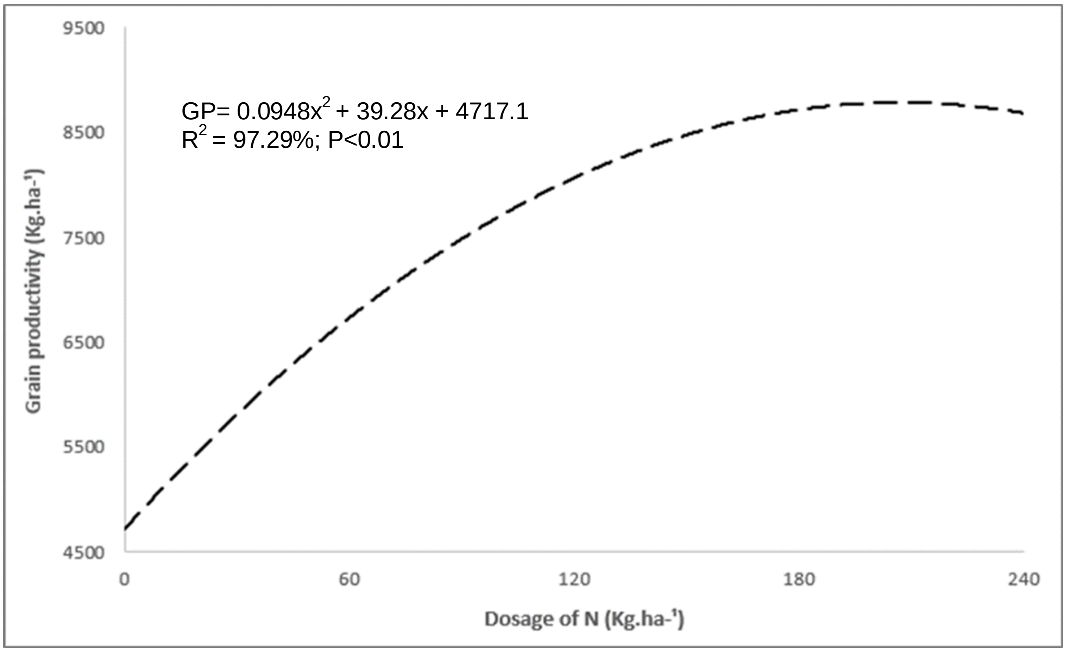

Figure 3. Grain productivity in function of the N doses in coverage.

340.92 and 103.8 lg ha^{-1} of N, respectively.

Pavinato et al. (2008) state that the maximum corn grain productivity under sprinkler irrigation is achieved by applying 283 to 289 kg ha^{-1} N, however, the maximum economic efficiency occurs with 156 to 158 kg ha^{-1} N, and emphasize that producers are using nitrogen fertilizer above the amount needed.

Conclusion

1. The genotype variety Incaper Capixaba 203 presents higher plants, with increased height of the first insertion spike, higher number of leaves and higher grain mass of the hybrid AG 1051, which on the other hand has larger diameter stems and more grains per spike.
2. With respect to productivity, there is no difference between the two genetic materials evaluated when subjected to N doses considered in this study and the estimated nitrogen dose that provides maximum grain yield is the 207.17 kg ha^{-1} N.

Conflict of interests

The authors have not declared any conflict of interests.

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REFERENCES

Carvalho RP, Pinho RGV, Davide LMC (2011). Desempenho de cultivares de milho quanto à eficiência de utilização de nitrogênio. Rev. Bras. Milho Sorgo 10(2):108-120.

Conab (2016). Companhia Nacional de Abastecimento, http://www.conab.gov.br/OlalaCMS/uploads/arquivos/16_06_09_16_49_15_boletim_graos_junho__2016_-_final.pdf (accessed in june de 2016).

Costa NR, Andreotti M, Gameiro RA, Pariz CM, Buzetti S, Lopes KSM (2012). Adubação nitrogenada no consórcio de milho com duas espécies de braquiária em sistema plantio direto. Pesqui. Agropecu. Bras. 47(8):1038-1047.

Cruz SCS, Pereira FRD, Santos JR, Albuquerque AW, Pereira RG (2008). Adubação nitrogenada para o milho cultivado em sistema plantio direto, no Estado de Alagoas. Res. Bras. Eng. Agríc. Ambient. 12(1):62-68.

Embrapa (2013). Empresa Brasileira de Pesquisa Agropecuária, Centro Nacional de Pesquisas de Solos. Sistema brasileiro de classificação de solos. Brasília 353 p.

Farinelli R, Lemos LB (2010). Produtividade e eficiência agronômica do milho em função da adubação nitrogenada e manejos do solo. Rev. Bras. Milho Sorgo 9(2):135-146.

Goes RJ, Rodrigues RAF, Takasu AT, Arf O (2013). Características agronômicas e produtividade do milho sob fontes e doses de nitrogênio em cobertura no inverno. Rev. Bras. Milho Sorgo 12(3):250-259.

Lange A, Caione G, Schoninger EL, Silva RG (2014). Produtividade de milho safrinha em consórcio com capim-maranduem função de fontes e doses de nitrogênio em cobertura. Rev. Bras. Milho Sorgo 13(1):35-47.

Lourente ERP, Ontocelli R, Souza LCF, Gonçalves MC, Marchetti ME, Rodrigues ET (2007). Culturas antecessoras, doses e fontes de nitrogênio nos componentes de produção do milho. Acta Sci. Agron. 29(1):55-61.

Mendes MC, Rossi ES, Faria MV, Albuquerque CJB, Rosário JG

(2011). Efeitos de níveis de adubação nitrogenada e densidade de semeadura na cultura do milho no Centro-sul do Paraná. Pesqui. Aplic. Agrotecnol. 4(2):176-184.
Nascimento FH (2013). Avaliação do efeito orográfico na distribuição da precipitação em Fundão e Santa Teresa no período de 1947 a 2012. Esp. Ciênc. Hum. Nat. 1:99.
Pavinato PS, Ceretta CA, Girotto E, Moreira ICL (2008). Nitrogênio e potássio em milho irrigado: análise técnica e econômica da fertilização. Ciênc. Rural 38(2):358-364.
Prezotti LC, Gomes JA, Dadalto GG, Oliveira JA (2007). Manual de recomendação de calagem e adubação para o Estado do Espírito Santo - 5º Aproximação. Vitória: SEEA/INCAPER/CEDAGRO 305 p.
Santos LPD, Aquino LA, Nunes PHMP, Xavier FO (2013). Doses de nitrogênio na cultura do milho para altas produtividades de grãos. Rev. Bras. Milho Sorgo 12(3):270-279.
Sichocki D, Gott RM, Fuga CAG, Aquino LA, Ruas RAA, Nunes PHMP (2014). Resposta do milho safrinha à doses de nitrogênio e de fósforo. Rev. Bras. Milho Sorgo 13(1):48-58.
Silva PRF, Strieder ML, Coser RPS, Rambo L, Sangoi L, Argenta G, Forsthofer EL, Silva AA (2005). Rendimento e teor de proteína bruta nos grãos de híbridos de milho com adubação nitrogenada de cobertura tardia. Sci. Agric. 62(5):487-492.
Vilela RG, Orivaldo ARF, Kappes C, Kaneko FH, Gitti DC, Ferreira JP (2012). Desempenho agronômico de híbridos de milho, em função da aplicação foliar de fungicidas. Biosci. J. 28(1):25-33.

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Full Length Research Paper

Assessment of fruit postharvest handling practices and losses in Bahir Dar, Ethiopia

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Demand for fresh fruit is steadily increasing in big cities of Northwestern Ethiopia. As a result, fruits are transported from nearby as well as long distance sources to urban centers such as Bahir Dar. The type of fruit crops available in the market and number of fruit retailers are increasing from time to time. However, the key challenge facing the sector is loss across the supply chain. Therefore, the objectives of this study were to analyze fruit marketing practices, document causes and extent of postharvest losses in Bahir Dar fruit market. The study was conducted in June 2016 using semi structured questionnaire. Thirty-one fruit retailers were randomly selected and interviewed to obtain information on their socio-economic characteristics, fruit marketing practices and postharvest losses. Data analyzed using SPSS statistical software. Results revealed that, 77.4% fruit retailers are less than 31 years old, 67.8% attended above primary school education, and 83.9% have less than six years fruit trading experience. Therefore, fruit retailers are young and educated but have very limited fruit trading experience. Of the seven fruit crops commonly sold in Bahir Dar market; mango, banana and avocado were the most prevalent. The average shelf life of fruits in retailers' hand is only 3 to 4 days and about 20% of the fruits purchased by retailers lost before reaching to consumers mainly due to inappropriate handling and lack of proper storage facility. Therefore, multifaceted interventions such as capacity development, improved fruit production and harvesting practice, and proper storage and transportation facilities establishment are required to reduce postharvest loss and extend fruit shelf-life.

Key words: Postharvest loss, fruits, shelf life, storage, Bahir Dar, nutrition security.

INTRODUCTION

Ethiopia has suitable agro-ecology to grow both temperate and tropical fruit crops. However, fruit production activity is at infant stage in most parts of the country including in Northwestern Ethiopia and both small scale fruit producers and traders have very limited knowledge and skill on fruit production and postharvest handling practices. In this connection high amount of fruits is expected to be wasted due to several inappropriate production and postharvest handling practices. Kughur et al. (2015) reported 48.5% fruit and vegetable postharvest loss in Nigeria. Similarly, Zenebe et al. (2015) reported 45.9% postharvest loss on banana in Ethiopia, of which about 15.7% was incurred at farm, 22.1% at whole sale and 8.1% at retailer levels. On the

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Table 1. Socio-economic characteristics of the respondents.

Variables	No. of respondents	% of respondents
Sex		
Female	15	48.4
Male	16	51.6
Age (years)		
≤20	4	12.9
21-30	20	64.5
≥31	7	22.6
Fruit trading experience (years)		
≤ 5	26	83.9
≥6	5	16.1
Level of education		
Illiterate	5	16.1
Primary school	5	16.1
Secondary school	15	48.4
College	6	19.4

other hand, Madrid (2011) estimated that post-harvest losses in developed countries are an average of 12% from production to retail warehouse, and an estimated 20% at retail stores and food service sites.

Improper harvesting and postharvest handling practices result in loss due to spoilage of the produce before reaching to consumers along with the loss in quality of the produce such as deterioration in appearance, taste and nutritional value. The high perishable nature of fruit, lack of storage facilities, mechanical injuries due to improper handling, packaging, transportation, and microbial infection are the major reasons for postharvest loss in fruits (Devkota et al., 2014). Zenebe et al. (2015) pointed out market distance, duration of transport, storage condition, storage duration, duration of ripening, ripening room types, means of transport, and experience in banana marketing as important determinants of the postharvest loss of banana in Ethiopia.

Higher postharvest losses not only reduce the availability of fruits but also result in increase in per unit prices of the produce and thus limit the accessibility by the majority of community segments. Kughur et al. (2015) pointed out the multiple effects of postharvest loss as going beyond the loss of the actual crop to include loss in the environment, resources, labor needed to produce the crop and livelihood of the individual involved in the production process. However, it is important to note that much is being invested to production compared to postharvest handling, though 30 to 50% of the produce is wasted in few days after harvest. So far there are very limited reports on the causes and amount of fruit postharvest loss in Ethiopia. However, there is no information on the cause and extent of fruit postharvest loss in Bahir Dar. Therefore, the present study was conducted to assess causes and estimate amount of fruit postharvest losses in Bahir Dar.

MATERIALS AND METHODS

Description of the study site

This study was conducted in Bahir Dar city, Northwestern Ethiopia. Bahir Dar city is found at about 565 km away from Addis Ababa on 11°38’ North latitude and 37°15’ East longitude. It is one of the leading tourist destination and fastest growing cities in Ethiopia with a population of 221,991 people (CSA, 2007). It is found in one of the high potential areas of Ethiopia for crop production. It is found on an average elevation of 1830 m above sea level and characterized by hot and humid weather with an average temperature of 29°C. It receives 1416 mm annual rainfall in 125 rainy days and has distinct dry and wet seasons. About 100 fruit retailers and juice shops are found in Bahir Dar city.

Sampling, data collection and analysis

Thirty-one respondents were randomly selected among 100 fruit retailers operating in Bahir Dar city. The survey was conducted in June 2016 using semi-structured questionnaire following individual interview method. Both qualitative and quantitative data including sex, age, education level and length of fruit marketing experience of respondents, type of fruit they are selling, type of packaging material, transportation method, storage facility, source of fruit, percentage of fruit loss, causes of fruit losses, percentage fruit loss in different seasons, possible uses of over-ripen fruits, and measures taken by respondents to reduce postharvest losses were collected using the questionnaire and analyzed using SPSS statistical software.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

Results of this study revealed equal participation of women and men in fruit retailing business in Bahir Dar market (Table 1). Therefore, men and women are equally

Table 2. Types and major sources of fruit crops sold by respondents.

Fruit crop	Number of respondents	Percentage of respondents	Major sources	Distance (km)
Mango	29	93.5	Andassa, Deke, Arjo, Arbaminch & Assosa	22-1236
Banana	27	87.1	Arbaminch	1052
Avocado	24	77.4	Mecha, Wondogent & Arbaminch	35-1052
Papaya	17	54.8	Andassa	22
Orange	13	41.9	Markos, Mersa & Awash	263-804
Pineapple	7	22.6	Awassa	865
Guava	4	12.9	Andassa	22

benefiting from fruit retailing business. In contrast to this finding, researchers in other African countries reported fruit marketing as women dominated business (Mashau et al., 2012; Kughur et al., 2015). This disagreement could be attributed to fruit marketing system and cultural differences.

Results in Table 1 show that 77.4% of respondents were less than 31 years old. Therefore, fruit retailing business in Bahir Dar city is dominated by youth and creating employment opportunity for the youth. According to the current situation, fruit retailing business can be started with limited capital or even by borrowing fruits from wholesalers. It can be run even on roadsides without requiring land or shop ownership. It is also less labor demanding activity compared to crop production. All these factors might contribute for the more engagement of youth in fruit retailing business. Youths are usually said to be open-minded compared to elders. Therefore, this is an opportunity to modernize the existing fruit marketing practice in the city through proper guidance or training.

Results indicated that 67.8% of respondents attended above primary school education (Table 1). Therefore, most fruit retailers in Bahir Dar city are educated. However, all respondents did not receive any training on fruit postharvest handling practices. Education is generally considered as an important variable that enhances adoption of new technologies (Sabo, 2006). Hence, there is an opportunity to reduce fruit postharvest loss in Bahir Dar city through training and demonstrating various postharvest technologies to fruit retailers.

Results revealed that 83.9% of respondents have been in fruit retailing business for less than six years (Table 1). Therefore, most fruit retailers have very limited practical experience on different fruit crops postharvest physiology and handling practices. Zenebe et al. (2015) identified experience in banana marketing as one of the important determinants of the postharvest loss of banana in Ethiopia.

Types and major sources of fruits sold in Bahir Dar market

During this assessment period, about seven fruit crops were available in Bahir Dar market and retailers were selling more than one fruit crops in their shop (Table 2). Mango (*Mangifera indica* L.), banana (*Musa cavendishii* L.) and avocado (*Persea americana* Mill.) were available in more than 75% of the total respondents shop. On the other hand, guava (*Psidium guajava* L.) and pineapple (*Ananas comosus* L. Merr) were available only in less than 25% of the respondents shop. Retailers select the type of fruit crops they are selling primarily based on consumers demand and harvesting season of the crop. The number of fruit crops sold by a retailer ranged from one to six. About 87.1% of respondents sell more than two fruit crops. Only banana and mango has few specialized retailers. Therefore, storing and selling of different fruit crops in a very small shop will increase postharvest losses.

The sources of fruit crops sold in Bahir Dar market were diverse (Table 2). This could be since most fruit crops have seasonal fruit bearing characteristics. Of all the fruit crops, mango, avocado and sweet orange were supplied from diverse and distant areas. Similarly, banana and pineapple were supplied throughout the year from very far places such as Arbaminch and Awassa, respectively. Only papaya and guava were supplied from nearby areas. Therefore, transporting fruits from distant areas as far as 1236 km might contribute for the prevailing high postharvest loss.

Fruit transportation method

Retailers purchase fruits both from wholesalers and producers, and transport both from distant and nearby areas. Therefore, they are using different transportation methods (Table 3). About 77.4% of respondents reported that fruits are transported by trucks usually from distant areas but these vehicles do not have ventilation facility to transport highly perishable commodities like fruit. Cart and laborers are also used for short distance fruit transportation. All transportation methods predispose fruits to heat buildup and mechanical damage. Therefore, the present fruit transportation method contributes for fruit postharvest loss in Bahir Dar market. Seid et al. (2013) reported pack animals as major transportation system of

Table 3. Fruit transportation methods and packaging materials.

Transportation method	Number of respondents	Percentage	Packaging material	Number of respondents	Percentage
Truck	24	77.4	Wooden box	29	93.5
Manual labor	9	29.0	Sack	5	16.1
Cart	7	22.6	Plastic box	1	3.2
Boat	1	3.2	On truck	3	9.7

Table 4. Causes of fruit postharvest losses at retailing shops.

Rank	Poor storage condition		Mechanical damage (rough handling)		Poor quality produce (disease, pest, premature)	
	No. of respondents	Percentage	No. of respondents	Percentage	No. of respondents	Percentage
Ranked 1st	17	54.8	14	45.2	0	0
Ranked 2nd	10	32.3	14	45.2	7	22.6
Ranked 3rd	4	12.9	3	9.6	24	77.4
Total	31	100.0	31	100.0	31	100.0

fruit from production site to the local market in South Wollo zone, Ethiopia.

Fruit packaging materials

Fruit packaging has significant importance in reducing postharvest losses through protecting fruits from mechanical damage, undesirable physiological changes and pathological deterioration during storage, transportation and marketing. In the study area, retailers use different packaging materials to transport and store fruit crops. About 93.5, 16.1 and 3.2% respondents reported wooden box, sack and plastic box as their fruit packaging materials, respectively. Retailers reported that, among different fruit crops mango and sweet orange are transported and stored using sack as packaging material. Likewise, Seid et al. (2013) reported sack as the major fruit packaging material in South Wollo zone, Ethiopia. Mango and banana are also transported without any packaging material just by spreading on the truck. Transporting fruits without packaging material will increase fruit spoilage by predisposing the fruit to mechanical damage during loading and unloading as well as during driving on rough road.

The most commonly used packaging material, wooden box, has 30 to 50 kg capacity and did not have cushioning material to absorb shocks during transportation. Therefore, it wounds fruits packed with it and contributing to postharvest loss. They also tightly pack fruit in a packaging material or in the truck without grading fruits based on ripening stage. This practice facilitates ripening process and contributes in shortening fruit shelf-life. Hence, the existing packaging material and practice need to be improved to reduce fruit postharvest losses (Table 3).

Causes of fruit postharvest loss

Causes of fruit postharvest losses are usually interrelated. Therefore, respondents requested to rank causes of fruit postharvest losses in terms of their contribution on fruit spoilage. These responses are given in Table 4. About 54.8% of the respondents ranked lack of appropriate storage facility as the primary cause for fruit postharvest losses. Fruit retailers' sale and store fruits in a very small shop with an average area of 6 to 12 m^2. Its wall and roof are made of metal and corrugated iron sheet, respectively. Therefore, its temperature rapidly rises during day time and rapidly cools during night time. Temperature fluctuations in the store affect the physiological process of fruits and enhance its rotting. In addition, it does not have ventilation or cooling facility and enough space to store different fruit crops separately. These situations contributed for the high postharvest losses.

In addition, 45.2% of respondents ranked mechanical injury due to rough handling during harvesting, transportation and storage as a primary cause for high postharvest losses in Bahir Dar market. From these observations, it is evident that the major factor causing the loss of the produce was the lack of storage facility followed by inappropriate packaging and poor handling of the produce, and finally poor quality of the produce. Our findings substantiate the report by Devkota et al. (2014)

Table 5. Shelf-life and postharvest losses of different fruit crops.

Fruit crop	Shelf-life (days)			Postharvest losses (%)
	Wet season	Dry season	Mean	
Avocado	4.2±2.7	3.3±1.5	3.8±2.1	23.1±14.9
Banana	3.8±1.3	2.6±1.3	3.2±1.3	20.7±12.9
Guava	2.8±1.7	3.5±3.3	3.2±2.5	16.8±9.7
Mango	4.4±2.7	3.9±1.8	4.2±2.3	23.7±12.7
Papaya	3.0±1.7	2.2±0.8	2.6±1.3	29.2±18.0
Pineapple	3.9±1.8	3.4±1.1	3.7±1.5	10.1±7.8
Sweet orange	5.3±2.2	3.7±2.0	4.5±2.1	16.4±13.4
Mean	3.9	3.2	3.6	20.0±12.8

who reported that lack of cold store and inappropriate packaging facility had significant effect on postharvest losses of fruit in Nepal. Similarly, Zenebe et al. (2015) identified storage condition and transportation practice as important determinants for the postharvest loss of banana in Ethiopia.

Postharvest losses of fruits

Table 5 shows the shelf-life and percentage of fruits lost from retailers in Bahir Dar market. On average, 20% of the fruit purchased by retailers were lost. Kughur et al. (2015) reported 35 to 45% postharvest loss on fruit and vegetable in Nigeria. About 20% postharvest loss is not affordable for a country with large number of food insecure population, particularly at a time when nutritional security is one of the top agenda, both locally and globally.

Among different fruit crops sold by retailers the postharvest loss of papaya, mango, and banana were above the overall average loss. On the other hand, the postharvest loss of pineapple, sweet orange, and guava were below the overall average loss. This variability is primarily attributed to their natural differences in perishability, quantity supplied to the market, and consumers demand to the crop.

The shelf-life of different fruit crops was assessed in dry and wet seasons by interviewing fruit retailers. Respondents reported that, the shelf-life of most fruit crops is short in the dry season compared in the wet season. This could be attributed to the high temperature prevailing during the dry season. High temperature enhance the ripening process subsequently shorten the shelf-life of fruits. Unlike other fruit crops the shelf-life of guava was longer in the dry season compared to in the wet season. Respondents observed relatively short shelf-life and high postharvest losses in January, February, March and April. On the other hand, they have observed relatively long shelf-life and low postharvest losses in June, July, August and September. Among all fruit crops, papaya had very short shelf-life while sweet orange had relatively long shelf-life (Table 5). Overall, the shelf-life of fruits in Bahir Dar market is very short compared to in other countries. For example, in India traders store banana, sweet orange, guava, mango and papaya up to 3 weeks, 16 weeks, 3 weeks, 4 to 7 weeks, and 1 to 2 weeks by regulating the store relative humidity and temperature at 85-90% and 5 to 13°C, respectively (Singh, 1996). This could be attributed to the hot weather prevailing in the area coupled to the poor storage condition. Traders did not have refrigerator or cold store to extend fruit shelf-life. Instead, they extend fruit shelf-life by cooling the room by spraying water on the floor, and separating ripen and non-ripen fruits and keeping in different boxes.

Postharvest loss minimizing strategies of retailers

In the study area, fruit retailers minimize fruit postharvest losses through the following strategies: they buy small quantity, clean mango and orange fruits, sort fruits according to their ripening stage, select and discard rotten or over ripen fruits every day, avoid frequent touching of fruits by hand, pack and store different fruit crops separately, spray water on the floor to cool the room through evaporation, protect fruits from dry wind by covering with news paper, raise fruit handling wooden box from the floor to enhance air circulation and keep fruits in the shaded part of the shop.

They have also forwarded the following suggestions to reduce postharvest losses: improve fruit quality through improving fruit production and harvesting practices, reduce mechanical damage of fruits through improving packaging material, transportation facility and loading and unloading practice, improve banana ripening practice through training ripeners and standardizing the ripening process, establish better fruit storage and marketing facility, promote the food value of fruits for consumers to create demand, and regulate fruit marketing through creating better linkage among producers, traders and consumers. On the other hand, traders in developed countries reduce fruit postharvest losses primarily by regulating the storage climatic condition (Singh, 1996).

Over ripen fruit management

Most fruit retailers dispose over ripen fruits as waste. However, few respondents (35.5%) reported the use of over ripen fruit as animal feed. They use over ripen banana, guava, mango, avocado and papaya to feed pigs. Fruit traders provide over ripen fruits to livestock owners free of charge, sometimes even by providing transport service. Over ripen fruits are also used to extract seed. About 22.6% of the respondents sell over ripen avocado, mango and papaya fruits to farmers at lower price (3 to 5 birr/kg) for seed extraction. Therefore, effort required to recycle over ripen fruits either by using as animal feed or preparing organic fertilizer through composting.

Conclusion

The result of this study revealed that, fruit trading is mainly handled by young and relatively educated individuals compared to fruit producers. However, their experience on fruit marketing is very limited and resulted in inappropriate postharvest handling. Inappropriate storage, packaging and transportation practices are identified as principal causes for the 20% fruit postharvest loss and very short fruit shelf-life (3 to 4 days) in the study area. About 20% postharvest loss is not affordable for a country with large number (40%) of food insecure population. Therefore, efforts required on fruit storage and transportation infrastructures establishment, fruit processing, and capacity development to reduce the recorded high fruit postharvest loss and make available for consumers throughout the year.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

CSA (2007). Summary and statistical report of the 2007 population and housing census: population size by age and sex. Addis Ababa, Ethiopia. P 118.

Devkota AR, Dhakal DD, Gautam DM, Dutta JP (2014). Assessment of fruit and vegetable losses at major wholesale markets in Nepal. Int. J. Appl. Sci. Biotechnol. 2(4):559-562.

Kughur PG, Iornenge GM, Ityonongu BE (2015). Effects of postharvest losses on selected fruits and vegetables among small-scale farmers in Gboko local government area of Benue State, Nigeria. Int. J. Innov. Sci. Res. 19(1):201-208.

Madrid M (2011). Reducing postharvest losses and improving fruit quality worldwide: the one-billion-dollar untapped business opportunity. [WWW document] URL http://www.fruitprofits.com/ing/articulo.asp?reg=26 .

Mashau ME, Moyane JN, Jideani IA (2012). Assessment of postharvest losses of fruits at Tshakhuma fruit market in Limpopo province, South Africa. Afr. J. Agric. Res. 7(29):4145-4150.

Sabo E (2006). Participatory assessment of the impact of women in agriculture programme of Borno State, Nigeria. J. Trop. Agric. 1(2):52-56.

Seid H, Hassen B, Yitbarek W (2013). Postharvest loss assessment of commercial horticultural crops in South Wollo, Ethiopia “challenges and opportunities”. Food Sci. Qual. Manage 17:34-39.

Singh A (1996). Fruit physiology and production. Kalyani Publishers, New Delhi, India, P 224

Zenebe W, Ali M, Derbew B, Zekarias S, Adam B (2015). Assessment of banana postharvest handling practices and losses in Ethiopia. J. Biol. Agric. Healthcare 5(17):82-96.

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Full Length Research Paper

Soil green manure and physic-hydric attributes under rubber tree plantation in São Paulo's western plateau, Brazil

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São Paulo's western plateau is a privileged region for rubber tree plantation, since it does not present favourable conditions for the development of plant disease. However, the soil in that region is still scarcely studied. This study has the objective of evaluating the effect of management practices applied between the lines of rubber trees (*Hevea brasiliensis*) in physic-hydric attributes of a red oxisol and red-yellow ultisol, in the city of Jaboticabal-SP, in random blocks with four repetitions. The following treatments were applied between the lines: harrowing, green manure application with *Pueraria phaseoloides* and trimmer. The quantified data were: soil permeability, clay content, disperse clay, flocculation degree, water retention curve and total porosity, for four soil layers (0-0.10; 0.10-0.20; 0.20-0.30; and 0.30-0.40 m). The studied soils presented differences regarding water permeability for the different treatments. Higher gravimetric humidity for lower tensions in both soils was observed. Green manure with pueraria favors increase in total porosity in the studied soils, contributing for increase in total porosity, humidity and permeability.

Key words: Oxisol, Ultisol, soil management, soil conservation.

INTRODUCTION

São Paulo's Plateou, in southwestern Brazil, is a region with around 14 million hectares with potential to rubber tree plantation for its climate characteristics, which ensure fast tree growth and are not favourable for *Microcyclus ulei*, responsible for the South American leaf blight, and for its light and deep soils (IAC, 2016).

However, the knowledge on which management practices cause less alterations in the physical properties is still very little and it is key for a better plantation development and soil conservation. The conventional management used in the region is harrowing, with some recommendations for trimmer and green manuring (Centurion et al., 2005). However, the management techniques have great influence in soils attributes and species development. Ribon et al. (2003), when studying Oxisols and Ultisols in the area, have observed that the management with trimmer favours the increase in soils density and reduce the soil's macro porosity, eventually causing harm to tree development. On the other hand, Centurion et al. (2005), when studying the influence of types of management in the soil's chemical properties and rubber tree nutritional state and development, observed that trimmer is important for the soil-plant system. Centurion et al. (1995) performed a study on rubber tree development in soils from São Paulo's plateau (Oxisols and Ultisols) and have verified that those have not presented limitations in physical properties, effective depth, texture and internal drainage in this crop's development.

Ultisols limitations refer to their high erosion susceptibility but they can, however, be corrected through the use of terraces, leveling and maintenance of the vegetation cover during the rain period. Regarding Oxisols, limitations were related to chemical properties, suggesting that this type of soils' management, especially for cultivation of deep root systems as deep as those in rubber trees, must include liming and phosphate covering with deep incorporation and gypsum, in order to neutralize toxic aluminum for soils low in nutrients. Proper soil management is critical for maintaining or altering its original physical properties at the bare minimum, especially those which are affected by compaction, such as infiltration, water retention and porosity. However, there are few information regarding physical properties from the soil in productivity of perennial cultivation. Ribon et al. (2014) have observed that green manure cultivation between cultivation lines (*Havea brasiliensis*) enables better distribution of bigger aggregates in the layer of 0-0.10 m, when compared to management with trimmers for Oxisols in São Paulo state. The authors have also observed that intensive soil movement reduces aggregate size for Oxisols and Ultisols. This structure modification and soil aggregation reflects directly in the soils' infiltration and water retention, inferring that the adopted management method may influence on this characteristics for rubber tree cultivation soils.

According to Bastos et al. (2005), aggregate formation and soil structure is established by soil colloids flocculation. Thereby, clay quantity, clay dispersed in water and flocculation degree are important attributes to be quantified after the adoption of different management methods in a soil given their influence on all other physical and physic-hydric soil attributes. Marchão et al. (2007) have observed that different soil managements (direct and conventional planting) have great control over alterations in soil's water retention curve (WRC) which reflects soils structural state and soil's capacity in retaining water either through porous system (water retained in higher tensions) or through clay surface (water retained in lower tensions). In this context, the present study has the objective to evaluate the effect of management practices applied between rubber tree (*Hevea brasiliensis*) lines in the soil's water retention curve, porosity, permeability and flocculation degree in a Red Oxisol and in a Red-Yellow Ultisols in São Paulo's plateau.

MATERIALS AND METHODS

In this study, two experiments were conducted, one in clayey in texture Red Oxisol (LV), from the city of Jaboticabal-SP (Lat. 21°S 15'W; long. 48°S 18'W; alt. 595 m) and the other in medium/sandy texture Red-Yellow Ultisols (PVA) from Tabapuã-SP (Lat. 20°S 57'W; long. 49°S 03'W; alt. 545 m.), both with rubber trees planted in 1992 (Embrapa, 2013). Both locations present Cwa climate, with rainy summer and dry winter, as shown in the Thornthwaite and Mather (1955). The experiment was installed in random blocks, with four repetitions, with an experimental parcel with 28 plants (four lines with seven plants), where the ten central plants were considered as the useful parcel. The other farming practices, such as sprouting, pest control and others were performed as appropriate. The fertilizing was performed according to the soil analysis, pursuant to Raij; Quaggio (1983).The following management methods were applied between rubber tree lines: harrowing, *Pueraria phaseoloides* (tropical Kudzu) and trimming. These managements have been utilized since the cultivation implementation in 1992, with plantation from of PB235 clone. Soil permeability is measured by the saturated soil's hydraulic conductivity, and was performed in the superficial layer (0.20m) through hydraulic charges of 0.05 and 0.10 m with Guelph permeameter, pursuant to Reynolds and Elrick, 1985).

Total clay content was determined in the layers of 0-0.10 m; 0.10-0.20 m; and 0.20-0.40 m, using NaOH as chemical spreaders, with slow agitation (16 h), though pipette method (Embrapa, 2011). Disperse clay had distilled water as a spreader. From the values of total and disperse clay, the flocculation degree was calculated. In the soils, the water retention curve and total porosity were obtained in the layers: 0-0.10, 0.10-0.20, 0.20-0.30 and 0.30-0.40 m. Water retention, in undeformed samples (54.3 cm^3), was determined in ceramic plate extractors, through drying, according to Richards (1965), in the tensions of: 0.006; 0.01; 0.033; 0.06; 0.1; 0.3 MPa. According to Reichardt (1988), the use of higher potentials, which correspond to field capacity, occurs more frequently in soils submitted to drainage in field conditions and, moreover, they make laboratory determinations simpler. From the soils water retention

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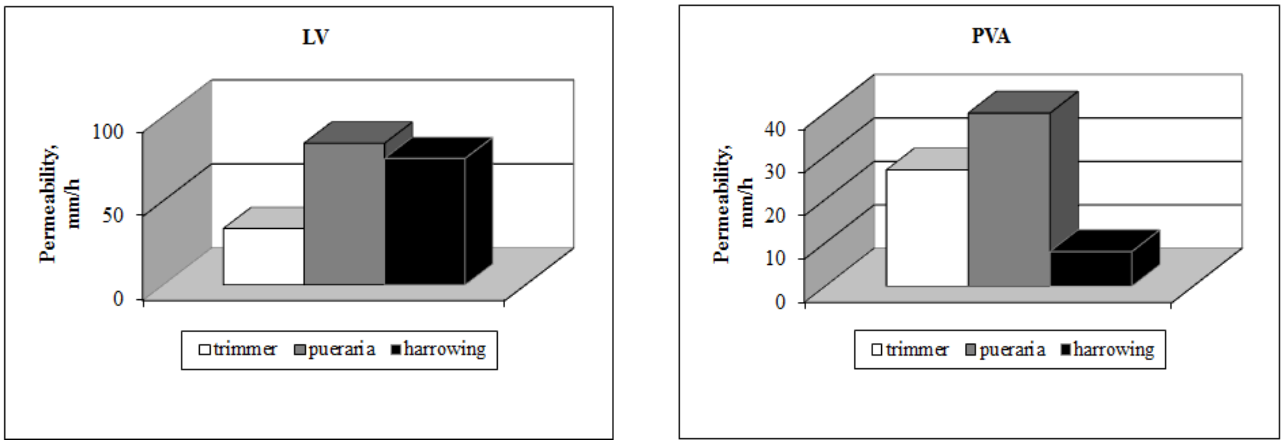

Figure 1. Permeability for the Oxisol (LV) and Red-Yellow Ultisol (PVA).

curves adjusted according to GENUCHTEN, total porosity was obtained, considering the total porosity obtained by the difference in saturated soil mass and oven dried soil mass. Variance analysis through F test and Tukey test were performed in order to compare the treatments' averages in different soil depths.

RESULTS AND DISCUSSION

Soil permeability was higher for management using pueraria for both studied soils. It is possible to observe that the soils with the same management method have presented differences regarding attributes, reflecting differences between the classes. For LV, trimming was the treatment with the lowest permeability, while for PVA, harrowing showed the lowest numbers (Figure 1).The results obtained for water permeability may be explained by the benefits of green manure in enhancing physical soil quality, especially by higher organic matter deposition. Ribon et al. (2014) have observed that the use of green manure is capable of improving the distribution of more stable aggregates in Oxisol and Ultisol, consequently improving water permeability. Alves et al. (2007), while studying physical restoration in Red Oxisols through green manure and sewage sludge, observed that different sources of organic matter have contributed for lower rates of soil density and higher levels of water infiltration. For total clay, clay dispersed in water and flocculation degree, no significant differences were observes for any of the treatments, in any depth, for both studied soils, LV and PVA (Table 1). For layer 0.10-0.20 m, different clay contents were observed in each treatment. In LV, total clay levels and dispersed clay rates were higher than those in PVA, for all layers, with increase in depth. Flocculation degrees were higher for PVA.

Lima Neto et al. (2009), while studying physical characterization in Oxisols and Ultisols, have observed similar results to those found in this study for flocculation degree. Pragana et al. (2011) explain that the organic matter level causes alterations in pH and in the soils' free cations, which influence in the repulsion and attraction forces between soil particles. It is a probable justification for the different results observed, since the soils in the present study presented different pedogenetic processes, even when under the same management method. Pragana et al. (2011) have not observed significant results for flocculation degree when studying different Oxisol managements. The authors justified their results explaining that this is a soils property that remains unaltered by management. The WRCs from LV may be observed in Figure 2. It is evident that with the increase in pressure, soil humidity decreases for all layers, and the curves have presented close values for all treatments studied (trimmer, pueraria and harrowing), with one exception in the superficial layer. The humidity values were higher in the layer 0-0.10 m, decreasing in the layer 0.10-0.20 m and increasing again for layers 0.20-0.30 and 0.30-0.40 m, where management influence is lower.

The results observed in PVA for WRC indicate that in the first two treatments, where higher water availability in macropores was verified, probably harrowing has altered soil disposition between macro and micropores (Figure 3). Meanwhile, the treatment with pueraria shows higher water availability in micropores, with higher pressure in the chamber being necessary to verify the humidity in micropores. Similarly to the findings of this study, Beutler et al. (2008) have also observed that water retention in the soil decreases as the potential increases in Red Oxisols under different cultivations (sugar cane, cotton and woods). Beutler et al. (2002), while studying Red Oxisols under cotton and sugar cane cultivations and native forests, have observed higher rates of macropores, verified by the WRC obtained in the superficial layers, due to higher rates of macropores. The same was seen in this study, except for layer 0-0.10 m of LV with pueraria. Marchão et al. (2007), while studying different

Table 1. Total Clay values (g.kg^{-1}) water dispersed clay (g.kg^{-1}) and flocculation degree (%)

Treatment	Layer (m)	Total clay	Dispersed clay	Flocculation degree
		Red oxisol (LV)		
Trimmer		44.75$^{a\ (1)}$	36.63^{a}	17.78^{a}
Pueraria	0-0.10	40.75^{a}	35.00^{a}	14.08^{a}
Harrowing		43.75^{a}	37.63^{a}	13.61^{a}
VC (%)		5.69	6.72	46.08
Trimmer		45,13^{ab}	37.38^{a}	17.28^{a}
Pueraria	0.10-0.20	42,88^{b}	35.75^{a}	16.58^{a}
Harrowing		46,25^{a}	38.13^{a}	17.43^{a}
VC (%)		4,42	5.12	26.48
Trimmer		48,75^{a}	38.38^{a}	21.05^{a}
Pueraria	0.20-0.40	47,25^{a}	38.50^{a}	18.26^{a}
Harrowing		48,88^{a}	38.63^{a}	20.68^{a}
VC (%)		3,82	4.80	27.72
		Red-yellow ultisol		
Trimmer		11.25^{a}	6.00^{a}	47.05^{a}
Pueraria	0-0.10	10.25^{a}	4.25^{a}	58.35^{a}
Harrowing		10.00^{a}	5.00^{a}	59.60^{a}
VC (%)		16.42	17.04	22.46
Trimmer		17.35^{a}	7.75^{a}	43.72^{a}
Pueraria	0.10-0.20	12.25^{a}	6.50^{a}	47.93^{a}
Harrowing		12.00^{a}	8.50^{a}	29.65^{a}
VC (%)		8.00	25.15	29.11
Trimmer		16.25^{a}	11.75^{a}	28.03^{a}
Pueraria	0.20-0.40	14.00^{a}	10.00^{a}	30.48^{a}
Harrowing		15.25^{a}	10.00^{a}	34.05^{a}
VC (%)		10.93	20.35	30.05

[(1)]Averages followed by the same letter in the column within the sampled depths, do not differ by 5% Tukey test.

soil managements (integrating crops with livestock, crops and native forest, Cerrado) have observed that WRC is an important attribute for comparing different management systems. According to the authors, soil management alters its physical quality, when compared to native areas. Although it has been observed higher humidity in superficial layers, intense use of machines may lower pores disposition in depths, through compaction.

Beutler et al. (2002) have noted that, besides soil management, texture, especially in clay content, influences in the WRC. According to Demattê (1988), in potentials higher than 0.2 Mpa, pore influence in water retention is absent, and is determined by the quantity of clay. In this study, low humidity was verified in tensions higher than the one above, for both soils. In comparison to this study's results, in layer 0-0.10 m more clay contents were found, which might justify the results observed for this particular layer. For the superficial layer (0-0.10 m), trimming and harrowing treatments have presented higher humidity between the tensions 0.0001-0.001 MPa, and lower humidity for higher pressures (>0.01 MPa) when compared to pueraria treatments. For PAV, it was observed that the WRC were close for all treatments studied, with similar humidity values in all layers. Possibly the soil's arenaceous structure in the surface prevented that differences were noted, as they were for LV. For total pore volume (TPV), it is clear that LV presents higher TPV than PVA, for all layers studied (Table 2). The superficial layers, 0.10-0.20, 0.20-0.30 and 0.30-0.40 m, did not present significant differences for treatments with trimmer, pueraria and harrow, inferring that the used managements do not influence in TPV in depth. For the superficial layer, significant differences were observed for both soils.

The treatments with pueraria and harrow in LV presented higher PTV than the treatment with trimmer, with almost 10% less. For PVA, the same behavior was observed, however, harrow treatment was intermediate, that is, did not differ neither from the treatment with pueraria, that presented that highest average, nor from the trimmer treatment, which presented the lowest

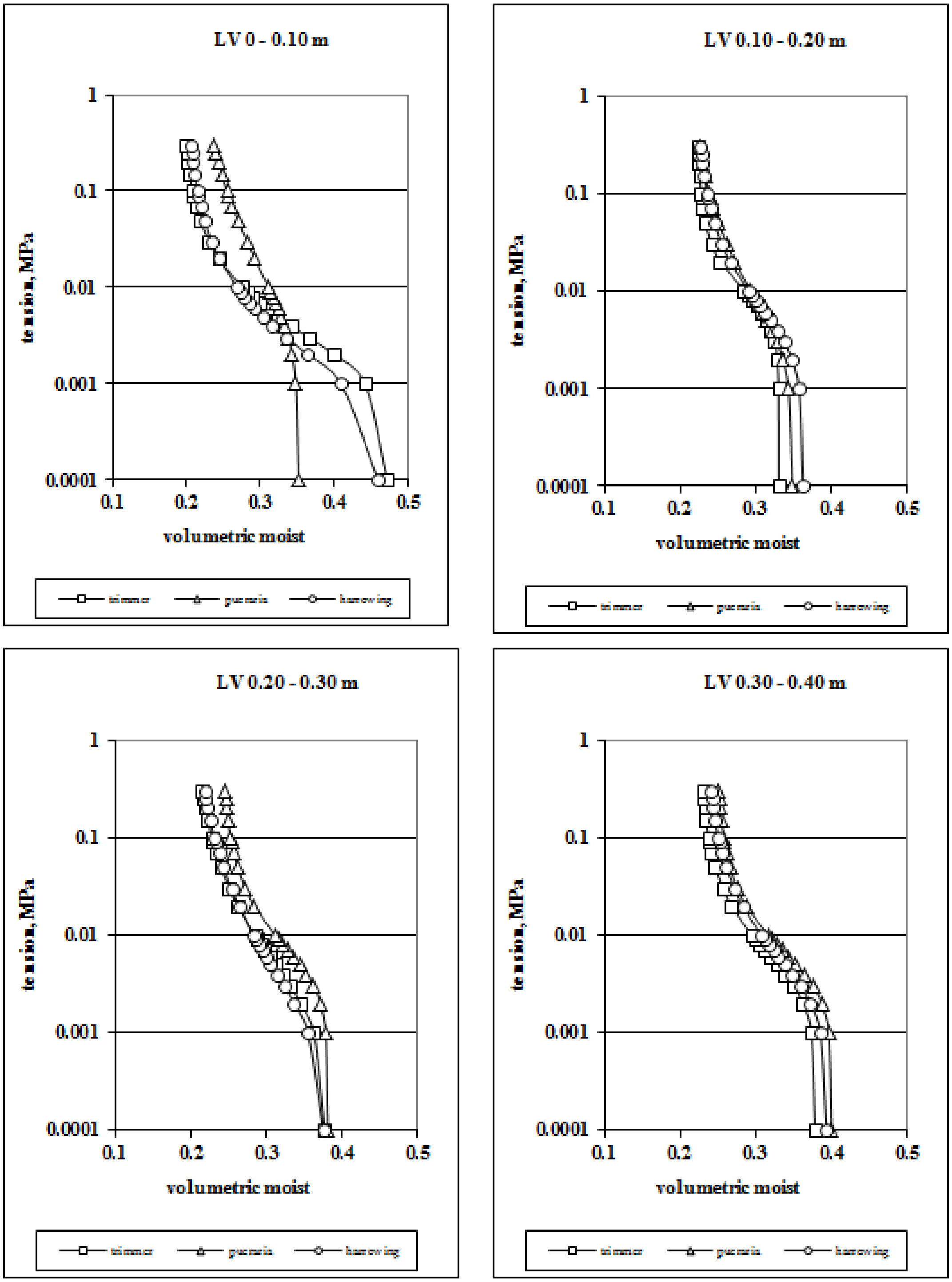

Figure 2. Water retention curves in soil obtained for the Oxisol (LV).

average, probably due to PVA's texture. The discrepancy of humidity values, higher for treatments with harrow and trimmer and lower for pueraria, which presented the lowest humidity, might be justified by macro and micropore relation. Treatments that involve soil tillage probably favor increase of macropores and decrease in micropores, while in the pueraria treatment, the opposite was observed. The increase of micropores might be beneficial to avoid losing water by percolation.

The highest averages of PTV were observed for

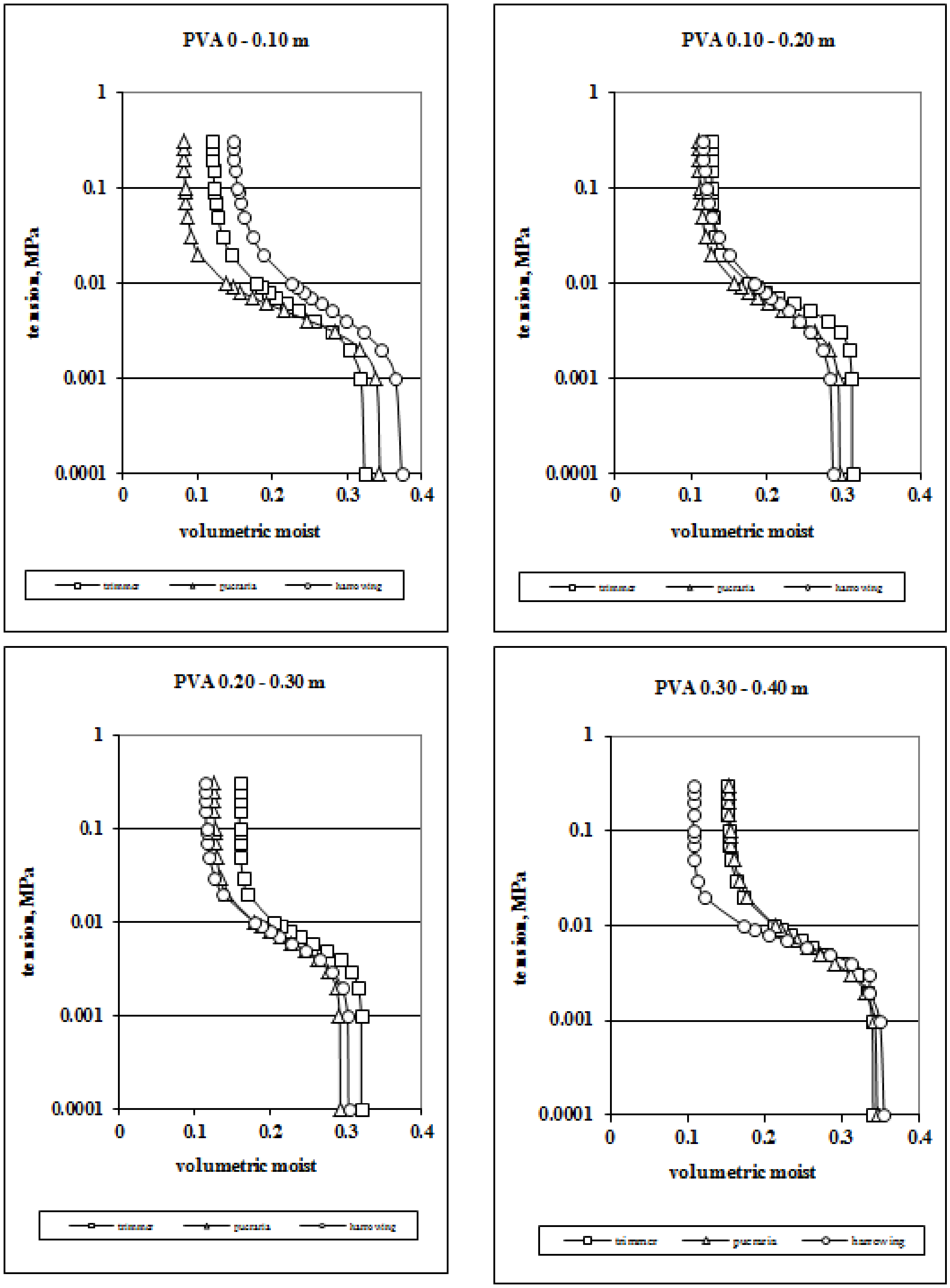

Figure 3. Water retention curves in soil obtained for the Ultisol (PVA).

pueraria treatment, for both soils, indicating that the treatment with green manure favors the increase of organic matter in the soil, with potential to improve the soils' pore arrangement. Spera et al. (2009), studying soils under integration systems, have observed values close to those observed in the woods, possibly due to maintenance of organic matter levels. Minatel et al. (2006), studying Red Oxisols, have noted that machine traffic and implements reduces total soil porosity, by increasing soil resistance to penetration, where direct

Table 2. Total Porosity for the soils obtained through the water retention curve in the soil

Layer (m)	Treatment	TPV (%)	
		Red oxisol	**Red-yellow ultisol**
0 - 0.10	Trimmer	36.29[b]	29.42[b]
	Pueraria	46.58[a]	36.45[a]
	Harrowing	48.28[a]	32.36[ab]
	VC (%)	3.63	6.58
	Trimmer	37.86[a]	30.62[a]
0.10 - 0.20	Pueraria	39.14[a]	29.69[a]
	Harrowing	38.88[a]	29.71[a]
	VC (%)	7.69	6.44
	Trimmer	38.40[a]	30.37[a]
0.20 - 0.30	Pueraria	38.10[a]	27.94[a]
	Harrowing	38.38[a]	28.33[a]
	VC (%)	4.10	5.45
	Trimmer	42.69[a]	34.17[a]
0.30 - 0.40	Pueraria	40.36[a]	30.01[a]
	Harrowing	40.33[a]	33.30[a]
	VC (%)	4.16	7.44

[(1)] Averages followed by the same letter in the column within the sampled depths, do not differ by 5% Tukey test.

sowing of green manure as an alternative to soothe the negative effects of soil compaction. Alves et al. (2001) have concluded that soils total porosity and water retention are influenced by green manure, providing a better environment in Dark-Red Oxisol under citric cultivation in São Paulo state.

Conclusion

Red Oxisol and Red-Yellow Ultisol presented different behavior for different management methods, indicating that the management must be adequate for each soil class. The fertilization management with pueraria favors the increase on total pore volume, contributing for an increase in humidity and permeability in Red Oxisol and Red-Yellow Ultisol, in this study`s conditions. The studied managements presented different influences for each soil in this study, indicating that the management must be properly designed for each soil class and each different region of plantation.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

Alves MC, Paulinho HB, Carvalho MAC, Souza ZM (2001). Adubação verde em Citus: influencia na porosidade e retenção de água de um Latossolo Vermelho-Escuro do noroeste do estado de São Paulo. Cadernos Lab. Xeolóxico de Laxe 26:267-279.

Alves MC, Suzuki LGAS, Suzuki LEAS (2007). Densidade do solo e infiltração de Água como indicadores da qualidade física de um Latossolo Vermelho distrófico em recuperação. Rev. Bras. Ciênc. Solo 31:617-625.

Bastos RS, Mendonça EDS, Alvarez V, Corrêa MM, Costa LM (2005). Formação e estabilização de agregados do solo influenciado por ciclos de umedecimento e secagem após adição de compostos orgânicos com diferentes características hidrofóbicas. Rev. Bras. Ciênc. Solo Campinas 29(1):21-31.

Beutler AN, Centurion JF, Souza ZM, Andrioli I, Roque CG (2002). Retenção de água em dois tipos de Latossolos sob diferentes usos. Rev. Bras. Ciênc. Solo 26:829-834.

Beutler, AN, da Silva F, Centurion JF, Leone CL (2008). Densidade do solo relativa e parâmetro “S” como indicadores da qualidade física para culturas anuais. Rev. Biol. Ciênc. Terra 8(2):27-36.

Centurion MAPC, Centurion JF, Roque CG, Prado RM, Natale W (2005). Efeito do manejo da entrelinha da seringueira sobre as propriedades químicas do solo, o estado nutricional e o crescimento. Rev. Árvore 29(2):185-193.

Centurion JFC, Centurion MAPC, Andrioli I (1995). Rubber growing soils of São Paulo, Brazil. Indian J. Nat. Rubber Res.8(2):75-84.

Demattê JLI (1988). Manejo de solos ácidos dos trópicos úmidos região amazônica. Campinas: Fundação Cargil 215 p.

EMBRAPA (2011). Manual de métodos de análise de solos. Rio de Janeiro: Embrapa solos 230 p.

EMBRAPA (2013). Sistema Brasileiro de classificação de Solos. 3.ed. Rio de Janeiro: Embrapa Solos 350 p.

IAC (2016). Centro de Seringueira e Sistemas Agroflorestais. 2016. Disponível em: <http://www.iac.sp.gov.br/areasdepesquisa/seringueira/edafoclimaticas.php>. Acesso em: 08 de novembro de 2016.

Lima Neto JA, Ribeiro MR, Corrêa MM, Souza Junior VS, Lima JFWF, Ferreira RFAL (2009). Caracterização e gênese do caráter coeso em Latossoloa Amarelos e Argissolos dos tabuleiros costeiros do estado de Alagoas. Rev. Bras. Ciênc. Solo 33:1001-1011.

Marchão RL, Balbino LC, Silva ED, Santos Júnior JD, Sá MD, Vilela L, Becquer T (2007). Qualidade Física de um Latossolo Vermelho sob Sistemas de Integração Lavoura-pecuária no Cerrado. Pesquisa Agropecuária Bras. Bras. 42(6):873-882.

Minatel AG, Andrioli I, Centurion JF, Natale W (2006). Efeitos da subsolagem e da adubação verde nas propriedades físicas do solo em pomar de citos. Eng. Agríc. 26(1):86-95.

Pragana RB, Ribeiro MR, Nobrega JCA, Ribeiro FMR, Costa JA (2011). Qualidade física de Latossolos Amarelos sob plantio direto na região do Cerrado Piauiense. Rev. Bras. Ciênc. Solo 36:1591-1600.

Quaggio JA (1983). Métodos de laboratório para calagem em solo. In: RAIJ, B. van; Bataglia, O. C.; Silva, N.M., coords. Acidez e calagem no Brasil. In: Reunião Bras. Fertil. Solo Campinas, Anais... Campinas, SP. 15:33-48.

Reichardt K (1988) . Capacidade de Campo. Revista Brasileira de Ciência do Solo, Campinas, SP 12(3):211-16.

Reynolds WD, Elrick DE (1985). *In situ* measurement of field-satured hydraulic conductivity, sorptivity, and the ∝ - parameter using the Guelph permeameter. Soil Sci. 140(4):292-302.

Richards LA (1965). Physical condition of water in soil. In: BLACK, C. A, ed. Methods of Soils Analysis. Madison Am. Soc. Agron. 1:228-151.

Ribon AA, Centurion JF, Centurion MAPC, Fernandes KL, Hermógenes VTL (2014). Alterações na estabilidade de agregados de Latossolo e Argissolo em função do manejo, na entrelinha da seringueira (*Havea brasiliensis*). Rev. Árvore 38(6):1065-1071.

Ribon AA, Centurion JF, Centurion MAPC, Pereira GT (2003). Densidade e resistência a penetração de solos cultivados com seringueira sob diferentes manejos. Acta Scient. Agron. 25(1):13-17.

Spera ST, Santos HPD, Fontaneli RS, Tomm GO (2009). Integração lavoura e pecuária e os atributos físicos de solo manejado sob sistema plantio direto. Rev. Bras. Ciênc. Solo 33:129-136.

Thornthwaite CW, Mather JR (1955). The water balance. Centerton, NJ: Drexel Institute of Technology - Laboratory of Climatology 8(1):104. (Publications Climatol.).


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