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Full Length Research Paper

Water use efficiency in the sugarcane cropping in different planting dates in Brazil

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In global terms, irrigation is a human activity with greater demand for fresh water and strategies are needed to minimize this consumption. Therefore, the objective of this study was to establish the sugarcane planting date, which results in a greater water use efficiency, considering the summer planting of the Northeast region of Brazil. The sugarcane cultivar was RB92579, drip irrigated, and the stage of the plant was first ratoon. The experimental design was a randomized complete block design, with four replications and five treatments referring to the planting date (PD) equivalent to the months of October (PD1), November (PD2), December (PD3), 2013, January (PD4) and February (PD5), 2014. Water use efficiency was defined as the ratio of the tonnes of sugar per hectare to the volume of water entering the system, either through irrigation, total rainfall plus irrigation or effective rainfall plus irrigation. The planting dates in October and January showed the highest water use efficiency, as well as higher agro-industry productivity and higher net revenue. Planting in October maximized the use of rainfall and, in November, minimized the use of irrigation water.

Key words: phenology, effective precipitation, evapotranspiration, soluble solids content, irrigation.

INTRODUCTION

The cultivation of sugar cane showed an initial expansion in the Brazilian Northeast, mainly in the Coastal Tablelands region. In this region, 70% of the total annual rainfall occurred in June and July, but this did not affect the growth of the 2014/2015 harvest, with a yield of 6.3% in relation to the previous harvest, indicating that the culture is adapted to the climate of the region (CONAB, 2014). Compared to other crops, sugarcane is the one that produces the highest amount of dry mass and energy per unit area in only one cut per year (Silva et al.,

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2014).

As a result of the population growth, irrigated agriculture is the activity that is growing more and more in Brazil and in the world, consequently having a high consumption of water compared to the other activity sectors, which represents almost 70% of total human blue water use (Gordon et al., 2010; Rost et al., 2008). This is the case of sugarcane that has a relatively high water consumption, and large scale increases in sugarcane farming compared to other crops which may increase overall catchment evapotranspiration (ET) and reduce stream flow (Bastidas-Obando et al., 2017). Thus, for an irrigated agriculture to be environmentally sustainable, an efficient use of water is necessary through an accurate monitoring of water application to provide the optimization of waters resources, which is so important for humanity (Cammalleri et al., 2014, Coelho et al., 2005).

When the input of water in the system (precipitation and/or irrigation) is greater than the output (evapotranspiration and/or percolation), the soil has a greater water availability. Therefore, if the water that enters the system via precipitation is used by the crop in a productive way, the water use efficiency of precipitation in the crop occurs. This will depend on the planting date and the development stages of the crop, that is, if water demand occurs at the stage of crop development that requires more water, there will be a loss in crop yield (Oliveira et al., 2011; Farias et al., 2008).

Therefore, when synchronizing the phenological phase of the crop with higher water requirement with the period of greater rainfall availability, it is possible to reduce the use of irrigation water without decreasing crop productivity. This alternative will either save the water that is spent on irrigation or reduce production costs, with the aim of achieving a good yield of the crop and of a sustainable way for the environment, by maximizing the use of rainfall and minimizing the use of irrigation. Therefore, the objective of this study was to establish the sugarcane planting date which results in a greater water use efficiency, considering irrigated planting in the Northeast region of Brazil.

MATERIALS AND METHODS

The field trials were conducted in an experimental area located in the Coruripe Mill, in the municipality of Coruripe, State of Alagoas, Brazil, with geographic coordinates of 10º01'29.15''S latitude and 35º16'24.86''E longitude, and altitude of 108 m (Figure 1). The climate of the region is rainy tropical type with dry summer and higher precipitations among the months of April and September, according to classification of Köppen. The average annual rainfall was 1,179 mm, with maximum, average and minimum temperature values of 29.5, 24.4 and 21.1°C, respectively. The average annual relative humidity was 82%.The soil of the experiment area was an Ultisol with plan relief, medium to clay texture, formed from the sediment of the Barreiras group, characteristic of the geomorphological unit of the Coastal Tablelands region (Jacomine et al., 1975).

The sugarcane cultivar used in the experiment was the RB92579 at the first ratoon, which shows good expansion and high productivity in the State of Alagoas. The experimental design was a randomized complete block design with four replications, with five planting periods being considered as treatment, totaling 20 experimental plots. The planting dates (PD) were equivalent to the months of October (PD1), November (PD2), December (PD3), January (PD4) and February (PD5), which are adopted by sugar mills in the State of Alagoas. The planting was conducted in double rows, with spacing of 0.5 m between single rows and 1.3 m between double rows.

The soil preparation consisted of sub soiling with a depth of 0.50 m to 0.60 m. The irrigation depths were applied daily by means of a subsurface drip system. The drippers were spaced 0.5 m from each other and buried at 0.25 m of soil depth, with a nominal flow rate of 1.0 L h^{-1}. The irrigation depths were applied according to the average of the daily reference evapotranspiration estimated in the previous week.

In order to estimate the reference evapotranspiration, the Penman-Monteith equation (Allen et al., 1998) was used, based on data obtained from an automatic climatological station located 5 km from the experiment site and named CORURIPE-A355, belonging to National Institute of Meteorology (INMET). The crop evapotranspiration (ETc) was estimated from reference evapotranspiration (ETo). For this, appropriate crop coefficients (Kc) were used for each stage of crop development and planting dates. The crop coefficients (Kc) were obtained by Silva et al. (2012). Soil water balance was performed daily and from this, it was possible to estimate the effective precipitation (EP) and the precipitation efficiency (PE), which is the ratio between EP and total precipitation (TP).

After each crop cycle, the physical productivity (tonnes of industrializable stalks per hectare - TISH) and the sugarcane quality parameters: sucrose content of the broth - SCB (%), industrial fiber content - Fiber(%), soluble solids content - ^{o}Brix(%), total recoverable sugar - TRS (kg Mg^{-1}) and tonnes of sugar per hectare - TSH (Mg ha^{-1}) were determined. The water use efficiency of each treatment based on TISH or TSH was determined by Equations 1, 2 and 3.

$$\mathrm{WUE(i)} = \frac{\mathrm{TISH\ or\ TSH}}{\mathrm{I}} = Kgm^{-3} \quad (1)$$

$$\mathrm{WUE(p+i)} = \frac{\mathrm{TISH\ or\ TSH}}{\mathrm{P+I}} = Kgm^{-3} \quad (2)$$

$$\mathrm{WUE(ep+i)} = \frac{\mathrm{TISH\ or\ TSH}}{\mathrm{EP+I}} = Kgm^{-3} \quad (3)$$

Where, WUE(i) is the water use efficiency of the irrigation (i); WUE(p+i) is the water use efficiency of precipitation plus irrigation(p + i); WUE(ep+i) is the water use efficiency of effective precipitation plus irrigation (ep + i); TISH is the tonnes of industrializable stalks per hectare (Mg ha^{-1}); TSH is the tonnes of sugar per hectare (Mgha^{-1}); I is the irrigation (m^3 ha^{-1}); P is the precipitation (m^3 ha^{-1}) and EP is the effective precipitation (m^3 ha^{-1}).

A preliminary economic analysis was carried out to determine the gross revenue (GR) for the month of each harvest, the total cost of water by subsurface drip irrigation (C) and the net revenue (NR). The total cost of water is the product of the cost of irrigation water by the irrigation depth applied. The cost of irrigation water was defined based on information on average operational costs of irrigation provided by the Talles Machado Mill, State of São Paulo, and Coruripe Mill, State of Alagoas, Brazil, whose value was US$ 0.75 per mm. Gross income is the product of TISH by TRS and by the value of kg of TRS (CONSECANA-AL 2015). Net income is the result of subtracting the total cost of water from gross income.

The physical and technological productivity data were submitted

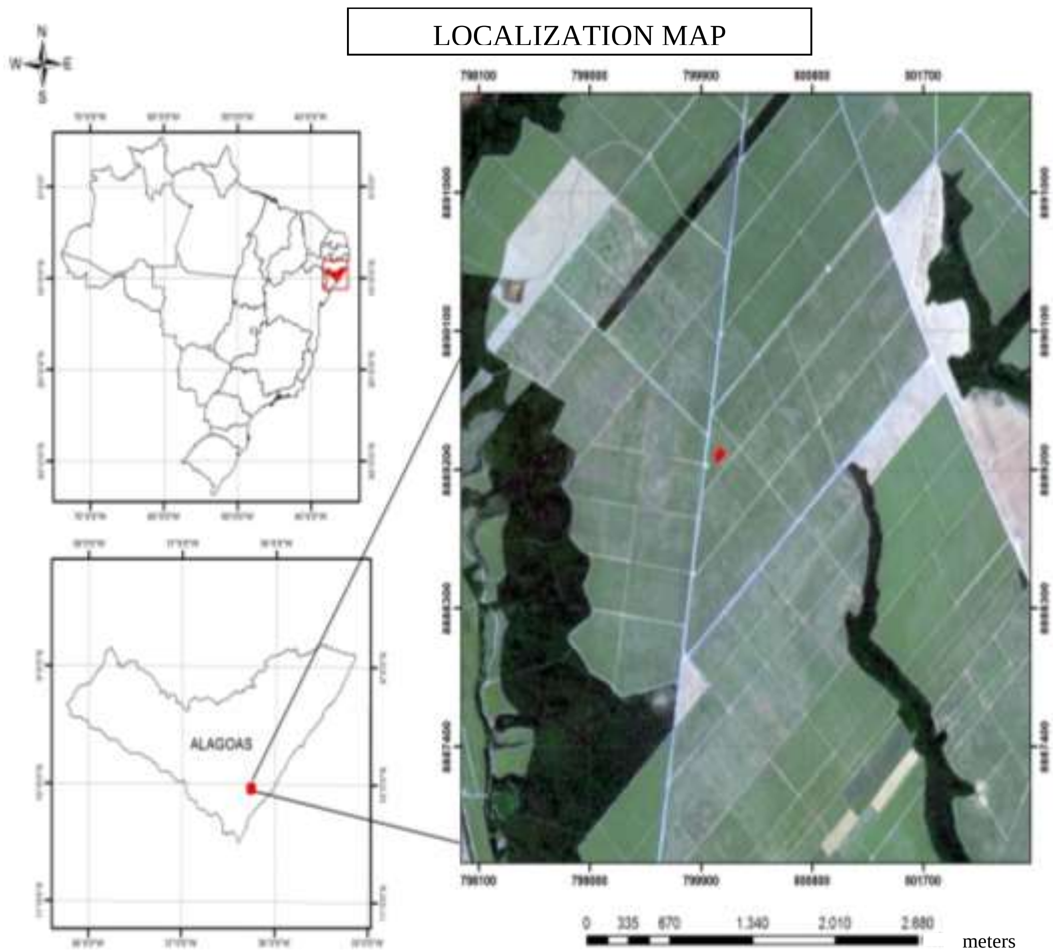

Figure 1. Location of the experimental area, with aerial view of the sugarcane fields of the Coruripe Plant, State of Alagoas.

to analysis of variance using the F test. The averages were compared by the Tukey test at 5% probability. For the analyzes, the statistical software SISVAR was used.

RESULTS AND DISCUSSION

In Figure 2, the water demand of sugarcane during its growing cycle was observed for each planting date, in relation to the precipitation distribution.

It was observed that the climate found in the region for the experimental period was favorable to the good development of the crop in its different stages of growth and different planting dates (Figure 2).

Most of the precipitation occurred in development phase 3 in all date of planting, mainly in PD2, PD3 and PD4 (Figure 2). In this development phase of the crop, high amounts of water were required to favor the maximum growth of the stalk, consequently being the phase of higher crop water demand. The period of greatest precipitation was between the months of April to September, exactly in the phase that the crop requires more water. Similar results were obtained by Silva et al. (2011) with the RB92-579 cultivar in the Juazeiro Municipality, State of Bahia, Brazil. Dantas Neto et al. (2006), in an experiment with the SP79-1011 cultivar conducted in the State of Paraíba, Brazil, found a higher concentration of precipitations from March to June, being within a characteristic range of months for the Northeast of Brazilian which period has a greater water availability of rains.

The total volume of water precipitation during the sugarcane cycle did not varied significantly among the evaluated planting dates, with the percentage difference between the highest and the lowest rain height of 3.6%; for the effective precipitation, the difference was 40% (Table 1). The low utilization of rainfall by the plant may be related to the type of soil and its low water storage capacity. Lima Neto et al. (2009), in their study of soil characterization in the Coastal Tablelands, verified that there is a compacted layer present in the depths of the soil of this region. This layer prevents the deepening of the roots, thus restricting the efficient use of water by

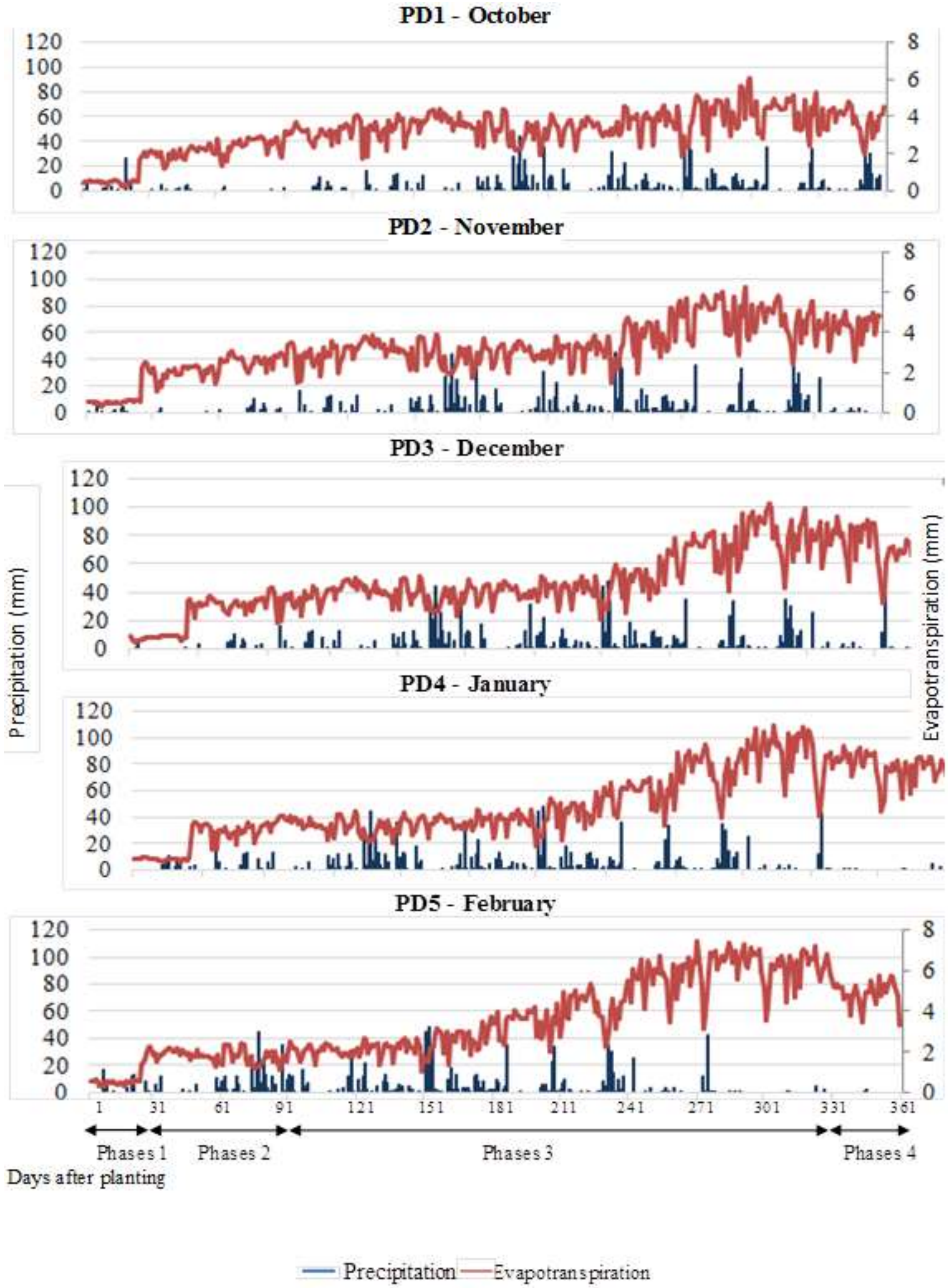

Figure 2. Behavior of precipitation and ETc during the growing cycle of sugarcane and the planting dates of October (PD1), November (PD2), December (PD3), January (PD4) and February (PD5).

them.

There was no statistically significant difference in relation to TISH and TSH; however, a trend of reduction of yield per hectare was observed during the harvest

Table 1. Amount of total precipitation (P), effective precipitation (EP), reference evapotranspiration (ETo), crop evapotranspiration (ETc), precipitation efficiency (PE) and accumulated irrigation depth (mm) for each planting date (PD) studied.

Planting date	P (mm)	EP (mm)	Eto (mm)	Etc (mm)	PE (%)	I (mm)
PD1	1,300.0	469.8	1,517.2	1,136.1	36.2	687.7
PD2	1,288.0	405.9	1,523.5	1,150.7	31.6	652.7
PD3	1,333.0	405.6	1,518.6	1,170.2	30.5	670.4
PD4	1,335.2	390.9	1,535.0	1,215.4	29.3	672.3
PD5	1,292.8	334.8	1,542.3	1,267.1	25.9	771.0
Mean	1,309.8	401.4	1,527.3	1,187,9	30.7	690.8

Table 2. Tonnes of industrializable stalks per hectare (TISH), total recoverable sugar (TRS), tonnes of sugar per hectare (TSH), sucrose content of the broth (SCB), sucrose content of cane (SCC), soluble solids content (°Brix) and industrial fiber content (Fibre) of the RB92579 sugarcane cultivar under different planting dates (PD).

Planting date	TISH (Mg ha^{-1})	TRS (Kg Mg^{-1})	TSH(Mg ha^{-1})	SCB (%)	SCC (%)	°Brix (%)	Fiber (%)
PD1	140.63^{a1}	143.79^{c}	20.24^{a}	17.65^{b}	14.76^{b}	19.49^{c}	12.75^{b}
PD2	125.82^{a}	142.36^{c}	17.89^{a}	18.32^{b}	14.56^{b}	19.93^{c}	13.25^{ab}
PD3	106.62^{a}	152.06^{cb}	16.25^{a}	18.90^{ab}	15.67^{ab}	20.71^{cb}	13.38^{ab}
PD4	126.92^{a}	160.75^{ab}	20.42^{a}	20.30^{a}	16.61^{a}	22.07^{a}	13.95^{a}
PD5	118.56^{a}	162.71^{a}	19.26^{a}	20.29^{a}	16.82^{a}	21.90^{ab}	13.20^{ab}
Mean	123.71	152.33	18.81	18.95	15.68	20.82	13.31
F[2]	ns	**	ns	**	**	**	*
CV%[2]	13.94	2.70	14.43	3.11	3.00	2.39	2.76
MSD[2]	40.11	10.29	6.43	1.53	1.17	1.25	1.00

[1]Means followed by the same letter in the column do not differ significantly from each other by the Tukey test. [2]**significant at 1% probability; *significant at 5%; ns: not significant by the F test (ANOVA). [3]CV, Coefficient of variation; MSD, Minimum significant difference.

time, due to the low availability of rainfall that occurred in phase 3 of the crop from the PD2, as could be observed in Table 2. The planting date PD2 resulted in lower irrigation water consumption, with a slide water application of 652.7 mm in the crop cycle, while PD1 and PD5 showed the greatest irrigation requirements. Thus, comparing the planting dates with lower and higher irrigation demand, it was observed that PD2 represented water saving of 118.3 mm in relation to PD5. The irrigation depths applied in PD4 and PD5 occurred due to the low effective precipitation found for them, in which it was necessary to supply the water deficit using irrigation water.

PD1 (140.63 Mg ha^{-1}) had the highest stalk yield, followed by PD4 (126.92 Mg ha^{-1}). PD1 and PD4 (20.44 and 20.22 Mg ha^{-1}) showed higher values of tonnes of sugar per hectare (TSH), while PD3 had lower yields of stems and sugarcane (Table 2).

In general, Meneses (2015) observed that there was a trend of decreasing productivity during the harvest time for the RB 92579 cultivar. This tendency was not clearly established in the cropping cycle of sugarcane in this study, due to an increase in yield in the last two planting dates (PD4 and PD5). Almeida et al. (2008) found the highest final production of stalk (136.22 t ha^{-1}) at the planting in October in the Coastal Table lands region of the State of Alagoas, and observed that it was a favorable month for good sugarcane management, since it is a period of favorable yield, as it was found in the this study.

The values of SCB, SCC and °Brix showed increase during the harvests. This fact was due to the relation between the maturation phase in the last three planting dates (PD3, PD4, and PD5) and the lack of rainfall in this period, since the water deficit in the maturation phase of sugarcane decreases the vegetative development, avoiding that the sugar translocates to the crop leaves, maintaining concentration in the stalks and favoring the final production of sugar.

It was observed in Table 3 that the planting date PD1 resulted in maximum water use efficiency on the basis of TISH, and the PD4 in the base of TSH, considering all the water intakes. The planting dates PD3 and PD5 were the ones that showed lower efficiency of water use in both water inputs and crop productive bases.

The highest water use efficiency of irrigation based on the TISH was observed in PD1 (20.45 kg m^{-3}) followed by PD2 (19.28 kg m^{-3}) and PD4 (18.88 kg m^{-3}). Silva et al.

Table 3. Values of water use efficiency (WUE) in the sugarcane cycle, RB 92579 cultivar, in five planting dates (PD): October (PD1), November (PD2), December (PD3), January (PD4) and February (PD5).

Cultivar	WUE (Kg m^{-3})	Planting date				
		PD1	PD2	PD3	PD4	PD5
RB92579	WUE(i) on a basis of TISH	20.45	19.28	15.90	18.88	15.38
	WUE(ep+i) on a basis of TISH	12.15	11.89	9.91	11.94	10.72
	WUE(p+i) on a basis of TISH	7.08	6.48	5.32	6.32	5.74
	WUE(i) on a basis of TSH	2.94	2.74	2.42	3.04	2.50
	WUE(ep+i) on a basis of TSH	1.75	1.69	1.51	1.92	1.74
	WUE(p+i) on a basis of TSH	1.02	0.92	0.81	1.02	0.93

Table 4. Economic performance of the sugarcane, RB 92579 cultivar, as a function of the planting dates.

Planting date	TISH[1] (Mg ha^{-1})	TRS[1] (Kg Mg^{-1})	TRS/ha[1]	US$/TRS[1]	GR[1] (US$/ha)	I[1] (mm)	TCI[1] (US$)	NR[1] (US$/ha)
PD1	140.63	143.79	20,221.0	0.1477	2,986.35	687.7	1,447.79	1,538.56
PD2	125.82	142.36	17,912.0	0.1454	2,603.80	652.7	1,374.11	1,229.69
PD3	106.62	152.06	16,213,0	0.1301	2,108.92	670.4	1,411.37	0,697.56
PD4	126.92	160.75	20,402.0	0.1300	2,654.85	672.3	1,415.37	1,237.48
PD5	118.56	162.71	19,291.0	0.1417	2,732.71	771.0	1,623.16	1,109.55
Mean	123.71	152.33	18,808.0	0.1390	2,617.33	690.8	1,454.36	1,162.57

[1]TISH, tonnes of industrializable stalks per hectare; TRS, total recoverable sugar; TRS/ha, total recoverable sugar per hectare; US$/TRS , amount paid to total recoverable sugar; GR, gross revenue; I , irrigation depth applied; TCI, Total cost of irrigation water; NR, net revenue.

(2013), using a randomized block design and two central pivots, found lower values of WUE(i) for the same cultivar. This fact was a result of lower sugarcane productivity and higher irrigation water consumption found by that author. In this study, the highest WUE(pe + i) on the basis of HCT was found in the planting date PD1 and on the basis of TAH in the PD4 (Table 3).

Oliveira et al. (2011), when developing an experiment with 11 sugarcane cultivars in the State of Pernambuco in the planting date of October 2006 with full irrigation, verified that the RB 92579 cultivar had a high water use efficiency of 18.3 kg m^{-3}, corroborating with the result obtained in this study for planting date in January (PD1).

The parameters used in the economic analysis to determine the planting date that provided the best financial return are shown in Table 4. The average net revenue was US$ 1,162.57 per hectare. In economic terms, the October and January planting dates resulted in higher net revenues.

Regarding the cost of irrigation, the difference between the highest and lowest costs was US$ 249.05. This cost was high due to the increase in the unit cost of water (US$ 0.75 mm^{-1}) in the study year, compared to that used by Resende (2013) who conducted similar analysis, however with values corrected for US$ 0.79 mm^{-1} of water.

Meneses (2015), studying planting dates for RB 92579 cultivar, found a net average income per hectare four times higher when compared to the value obtained in this study. This fact was due to the higher yield of stalk and sugar with lower irrigated depth (mean of 641.20 mm) and mainly due to the lower water cost (R$ 0.79 m^{-3}).

According to Vieira et al. (2014), in order to quantify the economic benefits of irrigation, it is necessary to know how to quantify the expected increase in productivity due to the increase in water applied. In this study, the highest irrigation depth was applied in the planting date PD5 and the lowest in the PD2, thus having a difference of 118.30 mm.

Conclusion

The planting date in October provided the maximization of the precipitation water use by the sugarcane, while planting date in November had minimized the crop use of irrigation water. Plantings carried out in October and January contributed to the crop showed higher yields of sugarcane stalk and sugar, respectively; as well as, when planted in October and January, sugarcane showed a greater efficiency in water use efficiency for all water intakes for both the tonnes of stalks per hectare and the tonnes of sugar per hectare. In summary, planting dates in October and January provided the maximization of the net revenue obtained with the cultivation of the sugarcane crop.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Allen RG, Pereira LS, Raes D, Smith M (1998). Crop evapotranspiration: guidelines for computing crop water requirements. Rome: FAO, 1998. (FAO. Irrigation and drainage paper, 56). 300 p.

Almeida ACS, Souza JL, Teodoro I, Barbosa GVS, Filho GM, Ferreira Junior RA (2008). Desenvolvimento vegetativo e produção de variedades de cana-de-açúcar em relação à disponibilidade hídrica e unidades térmicas. Ciência e Agrotécnica, Lavras 32:1441-1448.

Bastidas-Obando E, Bastiaanssen WGM, Jarmain C (2017). Estimation of transpiration fluxes from rainfed and irrigated sugarcane in South Africa using a canopy resistance and crop coefficient model. Agricultural Water Management 181:94-107.

Cammalleri C, Anderson MC, Gao F, Hain CR, Kustas WP (2014). Mapping daily evapotranspiration at field scales over rainfed and irrigated agricultural areas using remote sensing data fusion. Agricultural and Forest Meteorology 186:1-11.

CONAB (2014). Companhia Nacional de Abastecimento. Acompanhamento da safra brasileira de cana-de-açúcar 1:1-20.

CONSECANA-AL (2015). Conselho dos produtores de cana-de-açúcar, açúcar e álcool de Alagoas. Preço médio do ATR- Safra 2014/2015 <http://www.sindacucar-al.com.br/consecana>30 DEZ 2015.

Coelho EF, Filho MAC, Oliveira SL (2005). Agricultura irrigada: eficiência de irrigação e de uso de água. Bahia Agrícola 7:57-60.

Dantas Neto J, Figueredo JL da C, Farias CH de A, Azevedo HM, Azevedo CAV (2006). Resposta da cana-de-açúcar, primeira soca, a níveis de irrigação e adubação de cobertura. Revista Brasileira de Engenharia Agrícola e Ambiental 10:283-288.

Farias CHA, Fernandes PD, Azevedo HM, Dantas Neto J (2008). Índices de crescimento da cana-de-açúcarirrigada e de sequeiro no Estado da Paraíba. Revista Brasileira de Engenharia Agrícola e Ambiental 12:356-362.

Gordon LJ, Finlayson CM, Falkenmark M (2010). Managing water in agriculture for food production and other ecosystem services. AgriculturalWater Management 97:512-519.

Jacomine PKT, Cavalcanti AC, Pessoa SCP, Silveira CO (1975). Levantamento exploratório. Reconhecimento de solos do Estado de Alagoas. Recife: Embrapa, Centro de Pesquisas Pedológicas (Boletim Técnico, 35) 531 p.

Lima Neto JA, Ribeiro MR, Corrêa MM, Souza Junior VS, Lima JFWF, Ferreira RFAL (2009). Caracterização e gênese do caráter coeso em latossolos amarelos e argissolos dos tabuleiros costeiros do estado de Alagoas. Revista Brasileira de Ciência do Solo 33:1001-1011.

Meneses TN (2015). Avaliação de épocas de plantio em cultivo irrigado de cana-de-açúcar para maximização da eficiência de uso da água. São Cristovão: UFS/SE. 60 f. Dissertação Mestrado.

Oliveira ECA, Freire FJ,Oliveira AC,Neto DES,Rocha AT,Carvalho LA (2011). Produtividade, eficiência de uso da água e qualidade tecnológicade cana-de-açúcar submetida a diferentes regimes hídricos. Pesquisa Agropecuária Brasileira, Brasília 46:617-625.

Resende RS (2013). Irrigação de cana-de-açúcar. Revista Canavieiros 1:22-26.

Rost S, Gerten D, Bondeau A, Lucht W, Rohwer J, Schaphoff S (2008). Agricultural green and blue water consumption and its influence on the global water system. Water Resources Research 44:1-17.

Silva MA, Arantes MT, Rhein AFL,Gava GJC, Kolln OT (2014). Potencial produtivo da cana-de-açúcar sob irrigação por gotejamento em função de variedades e ciclos. Revista Brasileira de Engenharia Agrícola e Ambiental 18:241-249.

Silva TGF, Moura MSB, Zolnier S, Soares JM, Vieira VJS, Júnior WFG (2011). Demanda hídrica e eficiência do uso de água da cana-de-açúcar irrigada no semiárido brasileiro. Revista Brasileira de Engenharia Agrícola e Ambiental 15:1257-1265.

Silva TGF, Moura MSB, Zolnier S, Soares JM, Vieira VJS, Júnior WFG (2012). Requerimento hídrico e coeficiente de cultura da cana-de-açúcar irrigada no semiárido brasileiro. Revista Brasileira de Engenharia Agrícola e Ambiental 16(1):64-71.

Silva VPR, Silva BB, Albuquerque WG, Borges CJR, Sousa IF, Neto JD (2013). Crop coefficient, water requirements, yield and water use efficiency of sugarcane growth in Brazil. Agricultural Water Management 128:102-109.

Vieira GHS, Mantovani EC, Sediyama GC, Delazari FT (2014). Produtividade e rendimento industrial da cana-de-açúcar em função de lâminas de irrigação. Bioscience Journal 30(1):55-64.

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Cultivation of cactus pear forage propagated through the method of fractionation of cladode

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Between the varieties of Cactus Pear Forage resistant to Cochineal Carmine, the Orelha de Elefante Mexicana (OEM), Baiana (BA) and Miúda (MI) were found. The adoption of these varieties and dissemination in the areas damaged by this plague are directly related to provision of seeds cladodes. The method of propagation through fractionation of cladode is an alternative in cases where this availability is deficient. The experiment is aimed at analyzing the development of varieties of Cactus Pear Forage through propagation by fractionation of cladode. The experiment was conducted in randomized design blocks factorial 3×5 with three repetitions, corresponding to three varieties of Cactus Pear and five fractions of cladode (whole, 1/2 cladode, 1/4 cladode, 1/2 cladode inferior and 1/2 cladode superior). The ways of propagation did not affect the survival of the plant and number of cladodes. Major heights and widths of plants were obtained with whole cladodes. The whole cladode proportioned higher productivity in green and dry mass. The content of dry matter was superior in variety MI and the major productivity in OEM and BA. It was concluded that fractionation of cladode is mostly indicated in OEM but was absent in MI.

Key words: Cochineal carmine, nopalea, opuntia, resistant varieties.

INTRODUCTION

Livestock is an important source of income to a Semiarid Brazilian region, although it is subject to seasonability of forage offer that occurred as a function of temporal distribution of rains, resulting in periods of lower offer. The cultivation of xerophytic plants is one of the main alternatives to meet the demand of forage and water in period of drought (Ramos et al., 2015).

Between these xerophytic cultures, the Cactus Pear Forage stand out because it presents psychophysiological adaptations that makes its production viable, promoting the provision of forage in periods of prolonged drought. In the last decades the Cactus Pear have been incremented in animal feeding, however with the coming of Cochineal Carmine (*Dactylopius opuntiae*) the cultivation of Giant

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varieties (*Opuntia ficus-indica* (L.) Mill), susceptible to this plague and main variety used in the region has been precluded (Lopes et al., 2013). Therefore, the use of resistant variety has demonstrated an important way to control the plague.

Between the varieties identified as resistant to Cochineal Carmine, lies the Orelha de Elefante Mexicana (*Opuntia stricta*), Baiana (*Nopalea* species) and the Miúda (*Nopalea cochenillifera*). The adoption of these varieties by producers and the dissemination in areas reached by referred plague is directly related to availability of cladodes seeds and the rate of multiplication. Because it is a slow growing crop, and its propagation is made traditionally through the whole cladode, this constitutes a limitation in the required production time and the elevated quantity of necessary material for propagation.

As an alternative to traditional methods of propagation, there exists the method of minimal fractions of cladode, used in cases where the availability of vegetative material is small. It consists of fraction of cladode and contains the minimum of two areolas, as the lower the fraction the higher will be the time that it will take the seedling to be planted in the field (Vázquez et al., 2013). In this context, a simple way of multiplication, as the fractionation of cladode seed, aims to increase the quantity of material to plant and thus accelerate the propagation, leading to an important alternative to recompose the cactus plantations with varieties resistant in areas affected by the Cochineal Carmine. Based on this, the experiment had as objective to analyze the development of varieties of Cactus Pear forage resistant to Cochineal Carmine, through the propagation by fractionation of cladode.

MATERIALS AND METHODS

Localization of area

The experiment was conducted in field conditions, during 570 days, in Experimental Station of National Institute of Semiarid-INSA, located in the city of Campina Grande, State of Paraíba, situated in the Agreste Mesoregion of Paraiba, with latitude 07° 13’ 52’ W and altitude of 511 m. The weather was classified with the type Aw’i, according to climatic classification of Koppen and was considered as dry sub-humid.

Experimental delineation

The delineation in randomized design blocks was used in factorial scheme of 3 × 5 with three repetitions, corresponding to three varieties of Cactus Pear forage resistant to Cochineal Carmine in five types of fractionation of cladode.

Implantation of experiment

The process of implantation was divided into stages, viz: selections of cladodes seeds, fractionation and planting. In the first stage, cladodes seeds were homogeneously selected in terms of length, width, perimeter, thickness, and soundness of Orelha de Elefante Mexicana (*O. stricta*), Baiana (*Nopalea* spp.) and Miúda (*N. cochenillifera*) varieties of a research field in the Experimental Station of INSA. In the following stage, the fractionation of cladodes was carried out in harmony with the following treatments: whole cladodes (Figure 1A); 1/2 cladodes with longitudinal cut (Figure 1B); ¼ cladode with longitudinal and transversal cuts (Figure 1C); 1/2 cladode inferior (Figure 1D); and 1/2 cladode superior (Figure 1E).

After the fractionation, the fragments were separated by treatment and placed in a shade for a period of eight days, in a bid to heal the cuts. The planting was made in double ranks of 1.50 m × 0.50 m × 0.50 m in 45 portions, which composed of 28 plants each.

The plants were subjected to condition of irrigation, applying a blade of 1.5 L/plant every 8 days, when there were low or absence of precipitation in the area during the first 15 weeks.

The precipitation data were collected from the INSA Meteorologic Station throughout the entire period the experiment was conducted (Figure 2).

Analyzed variables

Ten plants were evaluated by treatment as follows: survival, through the counting of thriving plants; height and width of plant, with the use of tape measure; number of cladodes by plant, obtained through cladodes of each plant; green mass by measured plant through the weighing of all cladodes of the plant; carrying out the basal cladode based on values obtained; estimated productivity of green mass in tons by hectare; and the productivity of dry mass obtained by withdrawing samples of cladodes of each treatment, after the weighing of green mass, in different orders (primaries, secondary, tertiaries, etc). Approximately 800 g of samples were taken to the greenhouse for circulation of air and subjected to a temperature of ±65°C by a period of 120 h to dry the material. After drying of samples, data from weighed dry material was obtained by calculating the contents of dry mass of plant (Dry weight/Green weight × 100). The productivity of total dry mass was obtained through

$$\text{Productivity of total dry mass} = \frac{\text{Productions of fresh mass} \times \text{Respective levels of dry}}{100}$$

Statistical analyses

The data was subjected to analyses of variance and the averages compared by Tukey tests to 5% of probability, using the statistical program Sisvar (Ferreira, 2011).

RESULTS AND DISCUSSION

The analyses of variances of data did not show significant interaction between the factors studied by all variables. In Table 1 were presented the results to perceived survival, height and width of plant and number of cladodes by plant.

The different ways of propagation of Cactus Pear forage used in this experiment did not affect the survival of the plant and number of cladodes by plant; however, higher values of height and width of plant were obtained when the whole cladode and the ½ cladode (longitudinal

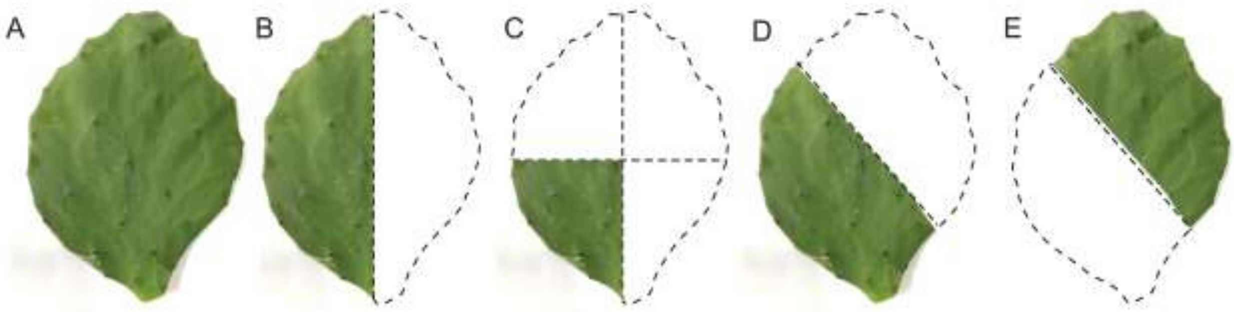

Figure 1. Exemplification of treatments with cladodes of Cactus Pear used for forrage.

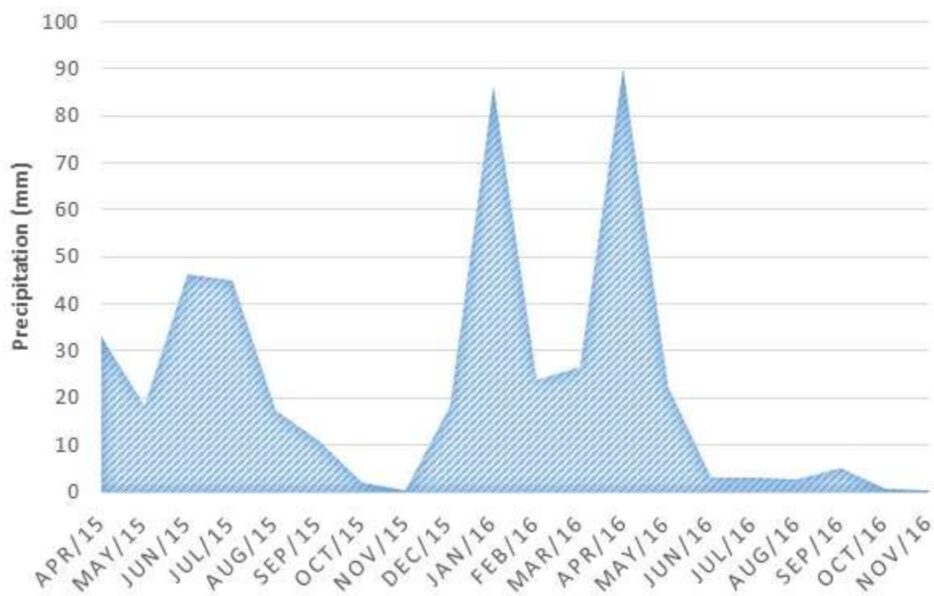

Figure 2. Precipitation in the area during the conduction of the experiment.
Source: INSA.

Table 1. Percentual of survival (PS), height (HP) and width of plant (WP) and the number of cladodes by plant (NCP) of Cactus Pear, in function of the forms of propagation.

Forms of propagation	PS (%)	HP (cm)	WP (cm)	NCP (Unity)
Whole	85^{a}	39.45^{a}	49.58^{a}	5.82^{a}
½ Cladode (Logitudinal Cut)	82^{a}	36.36^{ab}	40.30^{ab}	5.94^{a}
¼ Cladode (longitudinal and transversal cut)	70^{a}	31.29^{b}	32.58^{b}	3.54^{a}
½ cladode superior	71^{a}	33.26^{b}	38.69^{b}	5.09^{a}
½ cladode inferior	77^{a}	31.27^{b}	41.66^{ab}	3.57^{a}
CV%	13	13	19	19

Averages followed in the same letters in the columns are the same between them by the test of Tukey to 5% of probability.

cut) were used respectively.

Cavalcante et al. (2017), regarding vegetation house condition, in 45 days, obtained survival of 100% when using half of the fractioned cladode, and of 73.3% when the fraction was 1/6. Solano and Orihuela (2008) also observed a reduction of survival when fractionated on

Table 2. Percentual of survival (PS), height (HP) and width of plant (WP) and the number of cladodes by plant (NCP) of Cactus Pear, in function of the forms of varieties.

Variety	PS (%)	HP (cm)	WP (cm)	NCP (Unity)
Miúda	59[c]	30.24[b]	40.47[a]	7.29[a]
Baiana	77[b]	35.28[a]	40.50[a]	3.73[b]
Orelha de Elefante Mexicana	96[a]	37.47[a]	40.72[a]	3.36[b]
CV%	13	13	19	19

Averages followed in the same letters in the columns are the same between them by the test of Tukey to 5% of probability.

Table 3. Produtivity in green mass (PGM) and dry mass (PDM), the dry matter content (DMC) of Catctus Pear used for forrage, in function of forms of propagation.

Forms of propagation	PGM (t . ha^{-1})	PDM (t ha^{-1})	DCM (%)
Whole	22.96[a]	4.62[a]	20.41[a]
½ Cladode (Logitudinal Cut)	15.99[b]	3.43[ab]	21.45[a]
¼ Cladode (longitudinal and transversal cut)	10.01[c]	2.15[b]	21.68[a]
½ Cladode superior	13.90[bc]	3.24[ab]	22.83[a]
½ Cladode inferior	10.89[bc]	2.24[b]	21.21[a]
CV%	16	17	11

Averages followed in the same letters in the columns are the same between them by the test of Tukey to 5% of probability.

cladode in four and eight fractions. However, the two works mentioned above used only one variety whereas the present work used three.

Nonetheless, when the effect of varieties (Table 2) was observed, it could be verified that the variable survival revealed statistical differences with higher valor observed in variety Orelha de Elefante Mexicana (96%) and lower in variety Miúda (59%), indicating a reduction of 37% on last count when these two varieties are compared. The lower survival of the variety Miúda was related with the short height and weight of cladode, which resulted in lower fractions, lighter, and with less reserve.

In relation to number of cladodes, the varieties Orelha de Elefante Mexicana and Baiana had no difference between them, having as average 3.55 cladodes by plant. The variety Miúda presented superior valor from previous varieties, with 7.29 cladodes by plant, being the already expected result due to characteristics of gender, because according to Cavalcante et al. (2014), plants belonging to the gender Nopalea presents higher quantity of cladodes when compared to gender Opuntia which presented a higher quantity of yolks (Amorim et al., 2015). Also, Santos et al. (2013) justified the higher number of cladodes of Miúda variety and its precocity, a characteristic that will promote fast development of the plant in a small space of time.

Torres-Sales et al. (2016) also found higher number of cladodes from the variety Miuda when compared with a variety Alagoas. Lopes et al. (2013), regarding the variety Baiana, in 540 days after planting, obtained the range of 15.64 and 8.94 cladodes by plant in the treatments with whole cladodes and sections, respectively. Despite this, the authors did not specify the type of sectioning done in cladode.

When the variables were observed, height and width of the plant revealed difference only on height, with the variety Miúda value inferior to other varieties studied. Cavalcante et al. (2017) also observed that the numbers of cladodes were not affected by the fractionation, however it gave lower development of growth, taking into consideration the lower quantity of reserves.

Based on data previously presented, the variety Miúda can be considered more viable to planting of whole cladode due to the minor quantity of reserves that this material presented, thus avoiding the cost of replanting. Table 3 shows the results of productivity in the content of dry matter.

No difference was found between the dry matter contents of cladodes obtained from different forms of propagation. The content found was 21.5%, taking into consideration an elevated valor, since the Cactus Pear used for forage has around 10% of dry matter in its composition (Torres et al., 2009; Farias et al., 2000; Donato et al., 2014).

Regarding productivity, the results obtained highlighted the use of whole cladode with green and dry mass. This result was probably related to size of the cladode planted, because according to Lopes et al. (2013), plants that originated from fractioned or sectioned cladodes are morphologically small, with root less developed and physiologically sprout less than the conventional cladode because of the minimal reserve in photosynthesis inside

Table 4. Productivity in green mass (PGM) and dry mass (PDM), the dry matter content (DMC) of Catctus Pear used for forrage, in function of varieties.

Forms of propagation	PGM (t . ha^{-1})	PDM (t ha^{-1})	DCM (%)
Miúda	10.09^{b}	2.33^{b}	23.19^{a}
Baiana	15.47^{a}	3.25^{a}	21.11^{ab}
Orelha de Elefante Mexicana	18.69^{a}	3.84^{a}	20.25^{b}
CV%	16	17	11

Averages followed in the same letters in the columns are the same between them by the test of Tukey to 5% of probability.

of it. The conventional cladodes, besides being bigger morphologically had larger quantities of reserves and when planted, produced many roots; this occurred because the area of the cladode placed in the pit was superior to the selected.

In contrast, when ¼ of cladode was used, less values of productivity was obtained, highlighting the results obtained by Stambouli-Essassi et al. (2015) who observed that the growth of *O. ficus-indica* plants obtained in fractions of cladodes correlated with size of the fraction. However, despite the intermediate values of productivity obtained when ½ cladode (longitudinal cut) and ½ cladode superior were used, these fractions undergo viable propagation of varieties of Cactus Pear resistant, mainly when used as a longitudinal cut that would provide twice the material for planting.

When evaluating the productivity and content of dry matter in function of varieties (Table 4), it can be observed that the higher yields in both green and dry mass were obtained in the varieties Orelha de Elefante Mexicana and Baiana. In relation to dry matter content, the variety Miúda had highest concentration (23.19%) than the variety Orelha de Elefante Mexicana, although this variety did not differ statistically from Baiana.

Conclusion

The whole cladodes provided better results than the other studied varieties. The use of fractioned cladodes is mostly indicated in the variety Orelha de Elefante Mexicana but was absent in variety Miúda.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Amorim PL, Martuscello JA, Araújo Filho JT, Cunha DNFV, Jank L (2015). Morphological and productive characterization of cactus forage varietes. Revista Caatinga 28:230-238.

Cavalcante JMM, Queiroz ALB, Oliveira CC, Saraiva JFCS (2017). Desenvolvimento inicial de brotações com uso de 1/2 e 1/6 do cladódio na propagação da palma forrageira *Nopalea cochenillifera* var. Miúda. PUBVET 11:819-824.

Cavalcante LAD, Santos GRA, Silva LM, Fagundes JL, Silva MA (2014). Respostas de genótipos de palma forrageira a diferentes densidades de cultivo. Pesquisa Agropecuária Tropical 44:424-433.

Donato PER, Pires AJV, Donato SLR, Silva JÁ, Aquino AA (2014). Valor nutritivo da palma forrageira 'gigante' cultivada sob diferentes espaçamentos e doses de esterco bovino. Revista Caatinga 27:163-172.

Farias I, Lira MA, Santos DC, Tavares Filho JJ, Santos MVF, Fernandes APM, Santos VF (2000). Manejo de colheita e espaçamento da palma-forrageira, em consórcio com sorgo granífero, no agreste de Pernambuco. Pesquisa Agropecuária Brasileira 35:341-347.

Ferreira DF (2011). Sisvar: a computer statistical analysis system. Ciência e Agrotecnologia 35:1039-1042.

Lopes EB, Costa LB, Cordeiro Junior AF, Brito CH (2013). Rendimento e aspectos fenológicos de espécie de palma forrageira em relação ao cultivo com dois tipos de cladódios. Ciencia y Tecnología Agropecuaria 7:59-61.

Ramos JPF, Santos EM, Cruz GRB, Pinho RMA, Freitas PMD (2015). Effects of harvest management and manure levels on cactus pear productivity. Revista Caatinga 28:135-142.

Santos DC, Silva MC, Dubeux Junior JCB, Lira MA, SILVA RM (2013). Estratégias para Uso de Cactáceas em Zonas Semiáridas: Novas Cultivares e Uso Sustentável das Espécies Nativas. Revista Cientifica de Produção Animal 15:111-121.

Solano J, Orihuela A (2008). Supervivencia y producción de nopal para verdura (*Opuntia ficus-indica*) utilizando fracciones mínimas. Journal of the Professional Association for Cactus Development 10:198-208.

Stambouli-Essassi S, Harrabi R, Bouzid S, Harzallah-Skhiri F (2015). Evaluation of the efficiency of *Opuntia ficus-indica* cladode cuttings for vegetative multiplication. Notulae Botanicae Horti Agrobotanic 43:521-527.

Torres LCL, Ferreira MA, Guim A, Vilela MS, Guimarães AV, Silva EC (2009). Substituição da palma-gigante por palma-miúda em dietas para bovinos em crescimento e avaliação de indicadores internos. Revista Brasileira de Zootecnia 38:2264-2269.

Torres-Sales A, Leite MLMV, Andrade AP (2016). Adaptación de cultivares de nopal forrajero al semiárido estado de Paraíba, Brasil. Agronomía Mesoamericana 27:151-157.

Vázquez CG, Jacobo CM, Gallegos SJM (2013). Establecimiento de huertos comerciales de nopal tunero. In: Vázquez CG, Gallegos SJM, Jacobo CM. (eds.). Producción sustentable de tuna en San Luis Potosí. Colegio de Postgraduados - Fundación Produce San Luis Potosí. San Luis Potosí, SLP. pp. 80-96.

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Cattle milk production, processing and marketing situations of smallholder farmers in Telo district, Keffa zone, Ethiopia

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The study was conducted in Telo district of Keffa zone, SNNP Regional State with the aim of assessing milk production and milk use pattern. Cross-sectional study design was used to collect data from randomly sampled 156 households using survey questioner, farm visit and focus group discussion. Female headed farms were more frequent in urban. The average family size per household was 7 persons. 58.3% of HH were illiterate, mean cattle number was 7, higher (P<0.05) cattle number was found in rural than in urban. Cows are the only animals used for milk production. Milk from small ruminants was not consumed due to cultural taboo. Local indigenous cow contributes 99% of total milk production in the study area. The estimated average daily milk yield of local and cross breed cows was 1.4 and 7.28 L with an estimated lactation length of 8.47 and 9.92 months, respectively. In both urban and rural mixed crop-livestock production system frequency of milking was twice per day (morning and evening). There was no practice of milking in cases of stillbirth or death of calves. Calves were allowed to suckle prior to milking. All milk producers in the study area wash their hand before milking. Some 15% of the urban smallholders even wash udder and teat before milking. The milking utensils, commonly used in both production systems, were plastic materials. Nearly half (45%) of the respondents indicated that they wash milking utensil both before and after milking. The majority (93.7%) of rural (mixed crop-livestock production system) farm households process milk to butter. Only few (6.3%) households do not convert milk to butter but consume it as fermented milk "ergo". There was no practice of selling fresh milk in the rural area. Overall percentage of raw milk sold in the study area was 19.2%, with price of 15 to 20 ETB/L, indicating high demand and low supply of milk in the area.

Key words: Cattle, milk, production, processing, Telo.

INTRODUCTION

In Ethiopia, dairy production depends mainly on indigenous livestock genetic resources; more specifically on cattle, goats, camels and sheep. Cattle has the largest contribution (81.2%) of the total national annual milk output, followed by goats (7.9%), camels (6.3%) and sheep (4.6%) (CSA, 2009). Moreover, Ethiopia currently

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has the highest cattle population in Africa, estimated to be 59.5 million (CSA, 2016/2017). Out of these total cattle population, the female cattle constitute about 54.87% and the remaining 45.13% are male cattle. From these, milking cows number is about 10 million with an estimated annual total milk production of 5.2 billion liters of milk per year or 1.54 L per day per cow. In addition, it provides about 68 million tons of organic fertilizer and almost 617 million days in animal traction (Shapiro et al., 2017). Majority of these cattle are indigenous and owned by smallholder farmers under traditional management (Azage et al., 2000). Ethiopia's increasing production potential, human population, urbanization trends and household incomes are leading to a substantial increase in the demand for livestock products. In light of prevailing land-resources limitation, expecting the establishment of large scale commercial dairy farms in urban and peri-urban areas is unlikely. Thus, under Ethiopian condition, there is no doubt that the increase in milk supply to urban centers will continue to rely on smallholder dairy for many years to come (Mekonnen et al., 2006).

The average milk production from indigenous cows was 1.85 L/head per day and ranged from 1.24 in the rural lowland agropastoral system of Mieso to 2.31 in the rural highland system of Fogera. The average daily milk production for crossbred dairy cows was higher in urban (10.21-15.9 L/head per day) than peri-urban (9.5 L/head per day) systems. Lactation milk yield of indigenous dairy cows ranged from 271.4 L/head in the rural lowland agropastoral system to 434.8 kg/head in the peri-urban system. However, lactation length of indigenous animals was shorter and ranged from 5.9 months in rural lowland transhumance system to 9.8 months in the rural highland dairy system of Bure. Average daily milk production from camels in Mieso ranged from 7.6 L in the dry season to 13.2 L in wet season (Tegegn et al., 2013).

Consumption pattern and marketing of dairy products produced at home varied depending upon the amount of milk produced per household, dairy production system, market access, and season of the year, fasting period, and culture of the society. Rural dairy farmers have very little access to market fluid milk and milk is often processed into butter. The major dairy products commonly marketed include fresh milk, butter, ergo (fermented whole milk), cottage cheese and butter milk. Although marketing of milk is not common in Metema due to cultural reasons, it is well marketed in Mieso. The dominant milk products marketed across all the PLWs with the exception of urban and peri-urban system is butter followed by cottage cheese. In areas (e.g. rural highlands) where milk marketing is practiced, the amount marketed is very small due to lack of surplus production, the desire to process into milk products and lack of access to market. In market-oriented urban and peri-urban system fluid milk marketing is dominant being higher in urban than peri-urban system. Although both formal and informal milk marketing systems do exist, the latter is the dominant system across all the production systems (Tegegn et al., 2013).

The mainstay of Keffa population is rain fed subsistence agriculture and majority of these population practices mixed crop-livestock production system under traditional management. Telo Woreda is one of 11 Woreda in Keffa zone and found at distance of 45 km from Bonga or capital of Keffa zone. The main agriculture system in this area is livestock production especially mixed crop-livestock production, coffee production, spices, crops like barley, wheat, maize, teffe, inset, bean, pea and sorghum. Milk production is an integral part of the farming system in this Woreda. According to the "Woreda" agricultural and rural development report 2008, the total cattle population is about 81,993, from these milking cow contributes 13,346. Milk production is mainly from indigenous cows which are kept under smallholder farmers under traditional management system. Even if the area has potential for milk production, nothing has been studied on existing husbandry practices, major constraints associated with milk production, resources utilization or recycling between two integrated (livestock and crop) production systems.

Therefore, the objectives of this study were to assess the milk production, processing and marketing situation of smallholder farmers

MATERIALS AND METHODS

Study area

The study was conducted in Telo district, Keffa zone of SNNP Regional State. It is located at 500 km southwest of Addis Ababa and 45 km from Bonga or capital of Keffa. The total area coverage is 5569.4 ha and total population of 623,125. The altitude ranges from 2436 to 2451 m.a.s.l which represents typical highland environment. The main rainy season is from June to September with a mean annual rainfall of 1278 mm and the average daily temperature varies from 17 to 25°C. Four "kebeles" namely Oda, Dacha, Wora and Yama were selected as study sites based on potential for dairy. Oda is a small town, while the rest three Kebeles are rural areas of mixed crop livestock production system. Thus for the purpose of this study, the milk production system was classified as urban for Oda and rural mixed crop-livestock production systems for the rest three Kebeles (Figure 1).

Study design

Cross-sectional study design was conducted from September 2011 up to March 2012 by using different survey tools (semi-structured questioner, farm visit and group discussion).

Study population and sample size determination

The target sampling population constituted all households in the study area who owned milking cows. The sample size was determined by using Arsham (2007) with an estimated 8% confidence interval and 95% confidence level, the sample size studied was 156 smallholders.

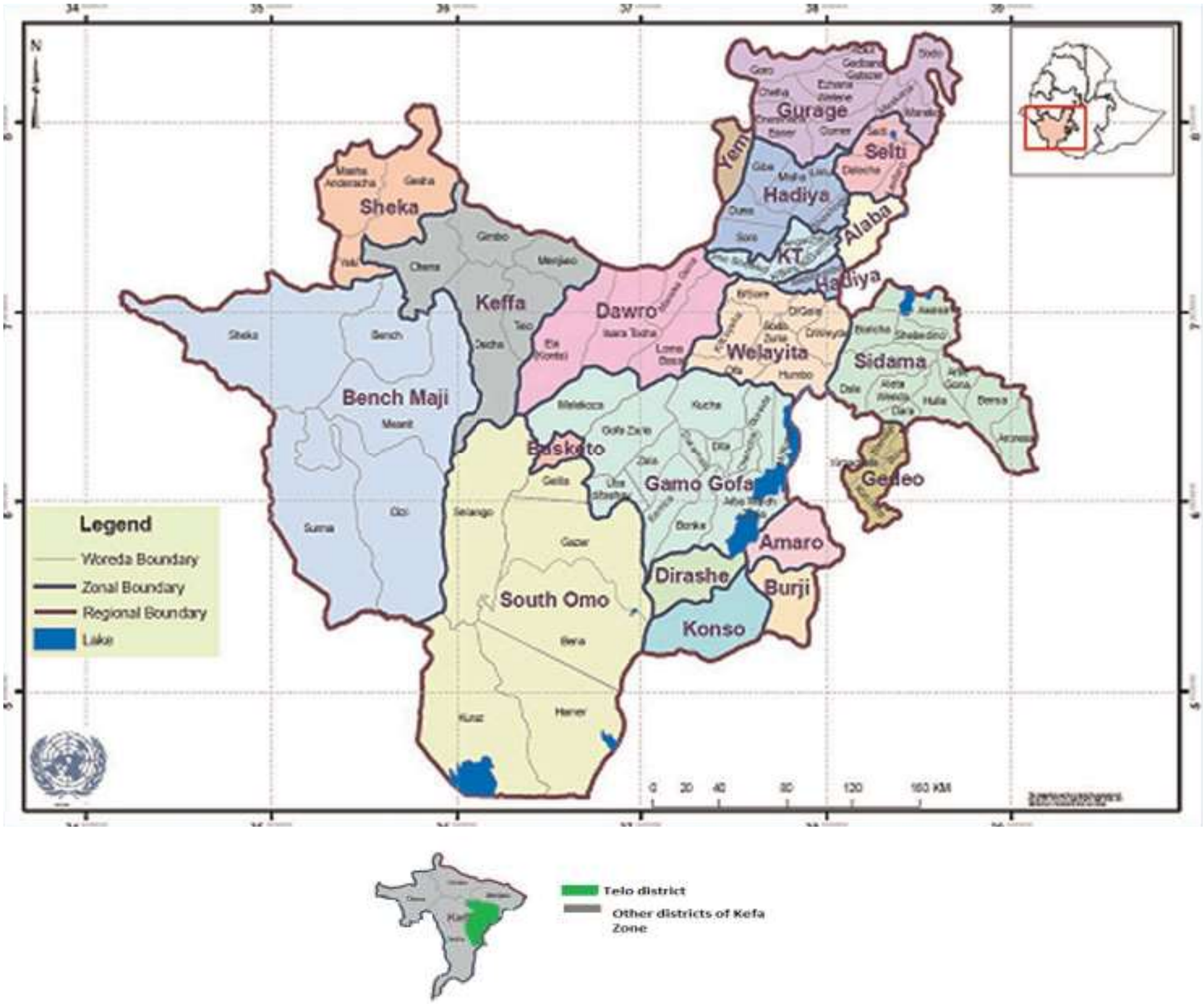

Figure 1. Map of study area.

$N=0.25/SE^2$

where N=sample size and SE=standard error assumed

The study participants' distribution in the four Kebeles (Dacha, Oda, Wora and Yama) was proportional to the smallholders having milking cows in each Kebele, shown in Table 3. The identification of study participants was done by using random (ballot) method.

Data collection

Secondary data

Secondary data from "Woreda" agriculture and rural development office and other sectors in our research project area were reviewed.

Questionnaire survey

A total of 156 smallholders were interviewed using a pre tested and semi-structured questionnaire. The latter contained both open and close ended questions. The overall purpose of the questionnaire was to determine demographic characteristics of household, understand the dairy cattle production situations, socioeconomic background of the smallholders' decision-making process on cattle milk production systems.

Farm inspection

A onetime farm inspection was done at the same time with the questionnaire interview to assess milking and milk handling practices.

Data entry and analysis

Descriptive statistics were used to summarize and analyze the data using statistical package for social sciences (SPSS) software version 17.0. Differences were considered significant for $P<0.05$.

Table 1. Average daily milk yield per head in liters and lactation length in months of cross and local breed cows as reported by smallholders in study area.

Variable		Crossbreed stage of lactation				Local cows stage of lactation			
		Early	Mid	Late	LL (month)	Early	Mid	Late	LL (month)
Rural	Mean	-	-	-	-	1.96	1.238	0.76	8.37
	N	-	-	-	-	123	123	123	123
	Max	-	-	-	-	3	2	2	24
	Mini	-	-	-	-	1	0.5	0	6
	St error	-	-	-	-	0.45	0.406	0.032	.207
Urban	Mean	9.75	7.88	6	9.75	2.52	1.667	1.02	8.85
	N	8	8	8	8	33	33	33	33
	Max	13	10	8	12	4	3	2	12
	Mini	6	4	2	8	2	0.5	0	4
	Std. error	0.75	0.71	0.732	0.526	0.103	0.0833	0.067	0.446
Total	Mean	9.75	7.88	6	9.75	2.08	1.329	0.81	8.47
	N	8	8	8	8	156	156	156	156
	Max	13	10	8	12	4	3	2	24
	Mini	6	4	2	8	1	0.5	0	4
	Std. error	0.75	0.718	0.732	0.526	0.045	0.390	0.030	0.188

Max=Maximum, mini=minimum, std. error=standard error, n=number of respondents, early lactation=calving to three month of lactation, mid lactation =four month to six month, Late lactation =above six to dry off.
Source: Survey Study (2012).

RESULTS

Milk production

In this study, cows are the only animals used for milk production. Milk from small ruminants was not consumed due to cultural taboo. Table 1 illustrates the daily milk yield and lactation length of local and crossbred cows. The result revealed that 99% of the total volume of milk produced is obtained from local cows and 1% from cross bred cows (Fresian and Zebu).

The average milk yield of local cows per day reported by the respondents was 2.08, 1.329 and 0.81 L for the early, mid and late lactations, respectively with an overall average of 1.4 L per day. The average daily milk yield of crossbred cows reported was 9.75, 7.88 and 6 L for the early, mid and late lactations, respectively with an overall average of 7.28 L per day. Average lactation length of local and cross breed cow in the study area was 8.47 and 9.92 months, respectively.

Milking and milk handling

According to the respondents, cows provide the only source of milk whereas milk from small ruminants is not consumed in the area because of cultural taboo. In both urban and rural mixed crop-livestock production system, frequency of milking was twice per day (morning and evening). There was no practice of milking in cases of stillbirth or death of calves. Calves were allowed to suckle prior to milking. All milk producers in the study area wash their hand before milking. Some 15% of the urban smallholders even wash udder and teat before milking. The milking utensils, commonly used in both production systems, were plastic materials. Nearly half (45%) of the respondents indicated that they wash milking utensil both before and after milking. The rest wash once per day (32.5%), once in two days (12.5%) or once in three days (10). The utensils were washed by using boiled plants like basil "besobla", "koseret", tejisar and leaves of "tikur enchet" . The large majority of urban (95.5%) and nearly half of the rural smallholders filter milk to separate some impurities by using pieces of tissues (urban producers) and plant fibers "Kancha" (rural producers) (Figure 2).

Milk processing

The majority (93.7%) of rural (mixed crop-livestock production system) farm households process milk to butter. Only few (6.3%) households do not convert milk to butter but consume it as fermented milk "ergo". In urban farm households, some (40%) practiced churning milk to butter especially during fastening periods where the demand for liquid milk drops. The dominant churning

Table 2. Milk marketing attribute in study area.

Variable		Rural		Urban		Total	
		N	Percent	N	Percent	N	Percent
Do sell milk?	Yes	0	0	30	90.9	30	19.2
	No	123	100	3	9.1	126	80.8
For whom:	Café	-	-	9	30	9	30
	Neighbor	-	-	21	70	21	70
Price/lit ETB	15-17	-	-	17	56.7	17	56.7
	18-20	-	-	13	43.3	13	43.3
Reason to not sell milk	Low productivity	17	13.8	3	100	20	15.9
	Lack of market accesses	77	62.6	0	0	77	61.1
	Culture	29	23.6	0	0	29	23

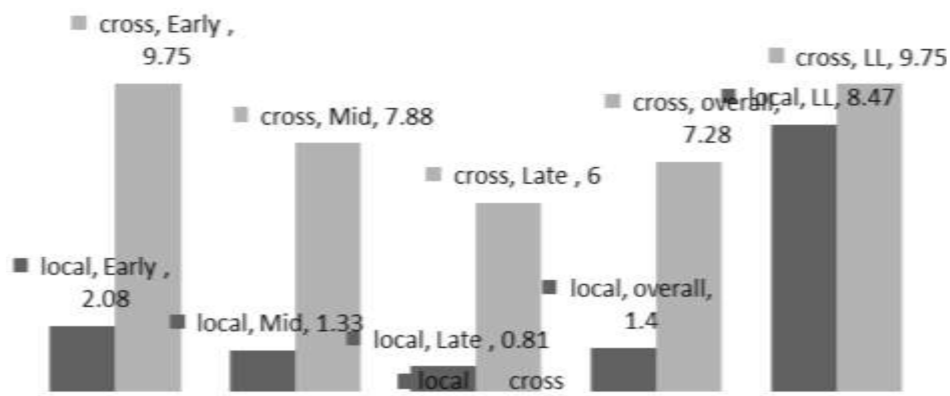

Figure 2. Average milk yield (L) per day per head with respect to stage of lactation and average lactation length (month) of local (n=156) and cross (n=8) breed cow in study area.

material in use was clay pot (78.5%). Plastic material called "*Jerikan*" are also replacing clay pots increasingly due to their durability handiness to operate by any age groups. The churning time was claimed as 2 to 2:30 h for clay pots 1 to 1:30 h for plastic churners.

Milk use categories and marketing features

Table 2 shows that milk use categories varied between urban and rural milk producers. The largest proportion of raw milk produced in rural farm households was processed. The overall indicated percentage of milk sold in the current study area was 19.2%. Raw milk marketing was informal and only practiced in urban milk production system. The milk marketing outlets were mostly (78%) neighborhoods and rarely (22%) café with modes of payment at monthly bases (locally they call it contract) and pre-paid with price per liter ranging from 15 to 20 ETB. The rural mixed crop-livestock producers do not sell milk due to lack of market access 69 (60%), low productivity 19 (16.5%) and cultural taboo 27 (23.5%). The rural milk producers sell butter and cottage cheese twice per week, Thursday and Sunday, which are large marketing days; there was no fixed price for butter and cottage cheese supplied by farmers. But the traders supplying only butter and sell 1 kg of butter 150 to 200 ETB. Selling of cheese by measuring was not common in the district. The consumers buy with an agreement.

DISCUSSION

In this study, the overall mean daily milk yield of local and cross breed cows were 1.4 and 7.28 L per day, respectively. This result is lower than the report of Adebabay (2009) for both categories. As per Adebabay's report, milk yield of local and crossbred cows were 1.82 and 8.25 L, respectively. On the other hand, the report of Asaminew and Eyasu (2009) for Mecha and Bahir Dar

Table 3. Milk use pattern in study area.

Variable		N	Mean± Std. Error	P-value
total milk produced	Rural	123	387.42±32.072	0.000
	urban	33	999.55±182.728	
	Total	156	516.90±49.998	
consumed at home	Rural	28	159.43±24.016	0.494
	Urban	32	186.34±29.928	
	Total	60	173.78±19.422	
Sold	Rural	-	-	-
	Urban	30	508.43±119.047	
	Total	30	508.43±119.047	
Processed	Rural	123	322.66±16.863	0.472
	Urban	33	359.18±75.410	
	Total	154	330.48±20.774	

Zuria districts (1.2 L for local and 5.2 L for crossbred cows) was lower than the present findings. The average milk yield of local cows in rural areas was significantly lower than that of urban local cows. This might be due to feed supplementation to cows in urban areas. The overall mean lactation length of local and cross bred cow in the current study was 8.47 month (254 days) and 9.75 month (292.5 days), respectively. The estimated lactation length of cross bred cow was comparable to the ideal lactation length of 305 days as defined by Foley et al. (1972).

Milk use pattern in the study area showed that the majority of milk producers did not consume fresh milk; the primary consumers of fresh milk in the study area were children below two years of age, old men and some vulnerable groups of women. The overall percentage of milk sold in the study area was 19.2%. This finding is lower than the total percentage of milk sold for urban 47% by Yitaye et al. (2009). The milk marketing system reported in this study district was informal with price differences for two main outlets (neighborhood and café with mode of payment contract and pre-paid). Tsehay (2002) reported that buying and selling prices of milk and milk products have seasonal variations and have no fixed price as such. As this result indicated the peak price of milk (20 ETB/L) indicated that there is high demand and low supply of milk in the area.

CONCLUSION AND RECOMMENDATIONS

It can be concluded that Telo district is of a highland agro-ecology with a favorable climate for dairy farming. The district however is not making use of this potential. Milk production systems are characterized by subsistence or hand to mouth milk production with traditional milk cow management system. Based on the aforementioned findings the following points are recommended:

(1) Quite large number of smallholders have long years of traditional experience in milk cattle production. Thus, training support to smallholders in modern dairy farming will help to improve their milk productivity and product quality and commercialization of the farm.
(2) Extension staff must also help smallholders to cope with social changes, such as changing gender roles and issues of access and control over resources, encouraging the farmers towards market-oriented milk production, and in establishing market access will fill the gap between demand and supply of milk.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERNCES

Adebabay K (2009). Characterization of milk production Systems, Marketing and on- farm evaluation of the effect of feed supplementation on milk yield and milk composition of cows at" Bure" district, Ethiopia. MSc Thesis, Bahr Dar University, Ethiopia.
Asaminew T, Eyassu S (2009). Smallholder Dairy Production System and Emergence of Dairy Cooperatives in "Bahir Dar Zuria" and "Mecha" Woredas, Northwestern Ethiopia. Dairy and Food Sciences 4:185-192. https://www.researchgate.net/publication/238733336
Azage T, Million T, Alemu Y, Yosef M (2000). Market oriented urban and peri -urban dairy systems, urban agricultural magazine, The Netherlands pp. 23-24.
Central Statistical Agency (CSA) (2009). Agricultural sample survey 2008/09. Report on livestock and livestock characteristics.Statistical bulletin 446. Addis Ababa.
Central Statistical Agency (CSA) (2017). Agricultural Sample Survey (Volume II: Report on Livestock and livestock characteristics (Private peasant holdings). Statistical Bulletin 585, Addis Ababa, Ethiopia:

Federal Democratic Republic of Ethiopia.

Shapiro BI, Gebru G, Desta S, Negassa A, Nigussie K, Aboset G, Mechale H (2017). *Ethiopia livestock sector analysis*. ILRI Project Report. Nairobi, Kenya: International Livestock Research Institute (ILRI).

Foley C, Bath L, Dickinson N, Tucker A (1972). Dairy cattle principles, practices, problems and profits, Philadelphia, USA. pp. 660-669

Kerealem E (2005). Honeybee production systems, opportunities and challenges in "Enebse Esar midir' Woreda and 'Amaro" Special Woreda. MSc Thesis, Alemaya University, Ethiopia.

Mekonnen H, Asmamaw K, Courreaw J (2006). Husbandry practices and health in smallholder dairy farms near Addis Abeba, Ethiopia. Preventive Veternary Medicine 74:99-107.

Tsehay R (2002). Small-scale milk marketing and processing in Ethiopia. In: Rangenkar D. and Thorpe W. (ed), Smallholder dairy production and marketing opportunities and constraints. Proceeding of south-south workshop held at NDDB (national dairy development board), March 13-16, 2001, Anand, India

Yitaye A, Wurzinger M, Azage T, Zollistch W (2009): Handling, processing andmarketing of milk in the North western Ethiopian highlands. Livestock Research for Rural Development 21:7. http://www.lrrd.org/lrrd21/7/ayen21097.htm

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