RESEARCH ARTICLE

SUCKER TYPE, HARVESTING PERIOD AND AGRO-MORPHOLOGICAL PARAMETERS FOR FASTER MULTIPLICATION OF *ALOE VERA* L.

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Abstract: *Aloe barbadensis* Miller has been used traditionally for heeling as a natural medicine. This crop attracting global market especially for cosmetic, pharmaceutical and food industry, therefore, greater demand for produce. It can be met out only through large scale cultivation. For this we need sufficient quality planting material of particular elites rich in bioactive chemicals, true to type and having short gestation period. Suckers are the primary and suitable source as propagating material. Agro-morphological parameters were observed maximum at four pair leaves from nine months harvest and minimum at one pair leaf from seven-month harvest. Maximum leaf and sucker were also observed in three and four pairs leaves at nine months after transplanting under well managed condition. The bacterial soft rot disease causes significant losses to the crop was also observed in the field. The leaf and sucker yield were increased with increase the sucker sizes.

Keywords: Aloe vera, Harvesting stage, Leaf yield, Soft rot, Sucker

INTRODUCTION

Aloe vera popularly known as aloe, is a xerophytic succulent perennial plant belongs to family Asphodelaceae and represented in the Liliaceae family, although it has its own family known as Alliaceae (Eshun and He, 9). The genus *Aloe* consisting more than 300 species, but there are only two species, *Aloe barbadensis* Miller and *Aloe aborescens* grown commercially (Tawaraya *et al.*, 17). *Aloe barbadensis* Miller and *A. chinensis*are considered the most biologically active species in India (Tawaraya *et al.*, 17). It is grown under subtropical and tropical parts of the world in various countries. The leaves are composed of three layers, an inner gel, a yellow sap and the outer thick layer of 15-20 cells called as rind (Eshun and He, 9; Surjushe *et al.*, 16). *Aloe vera* contained 98.5% water and the two major liquid sources are yellow latex and clear gel present in large parenchymatic cells of the leaf (Dagne *et al.*, 7). The plants generally grow 60 to 100 cm height in typical rosette shape with radically arranged leaves in two or three circles. The succulent leaves are pea green colour, 30-50 cm long and 10 cm broad at the base in triangular shape with spikes along the edges. *Aloe* leaf gel is major economical constituent used in variety of cosmetics including shampoos, sun blocks, lotions and skin creams. *Aloe* has been marketed as a remedy for healing wounds, burns, minor cuts, coughs, ulcers, gastritis, diabetes, cancer, headaches, arthritis, immune-system deficiencies and many other conditions when taken internally and externally (Rajeswari *et al.*, 15). There is a huge demand of aloe leaf for industry purpose (Aggarwal and Barna, 1) with an estimated annual market of $13 billion and which will increase up to 40% in coming five years (Grace *et al.*, 10). This global demand cannot be met through wild harvest. *Aloe* is a hardy species which demands less care for its cultivation and does not require very fertile land and lesser prone to pest and diseases. In India vast area remains underutilized due to low fertility and lack of resources, *Aloe* can be a good option for such areas for fetching high value. The presence of male sterility in flower is a major hurdle in rapid multiplication of crop by seeds. Therefore, suckers or offshoots are the primary source of propagation for commercial cultivation of crop. Generally, it produced 3-5 suckers per plant and all sized suckers are chosen carefully, dugout without damaging the parent plant, and directly planted in the field. The fertile seeds are derived through cross pollination (Botes *et al.*, 5) but it involves high heterogeneity of seedlings and maintaining cost because of frequent natural hybridization of the species (Alagukannan and Ganesh, 2). Seed propagated plants having long gestation period (3-4 years for harvestable stage) as compare to suckers in one year (Cristiano *et al.*, 6). Keeping this in view, the present work was taken on disease incidence and cost-effective propagation through suckers for easy, true to type and short gestation period using variant of sucker's sizes.

MATERIALS AND METHODS

Experimental site

The experiment was carried out research farm of ICAR-Directorate of Medicinal and Aromatic Plants Research, Boriavi, Anand, Gujarat during harvesting season of the year 2017-18. The experimental farm is located at 22°35 'N and 72°55 'E at an altitude of about 45.1 m above MSL.

Plant materials

Planting material of aloe vera was collected from previous crop grown on same farm at different location. The suckers were planted at a spacing of 60 × 60 cm with four different treatment i.e. one pair leaf, two pair leaves, three pair leaves and four pair

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leaves with six replications each in September, 2017. Harvesting was done at different time interval i.e. after seven, eight and nine months of transplanting.

Performance of yield contributing parameters and sucker's development

The plants selected for the analysis were uniform in age and five plants from each treatment were randomly chosen for observation. Observations for these four treatments were carried out for leaf yield, yield contributing and sucker's parameters. The values of different observations obtained from these plants were averaged to get the mean value separately according to treatments.

Bacterial soft rot disease

The experimental field was regularly visited and the soft rot disease was observed based on the symptoms. The observation on symptoms and disease incidence was measured on one; two; three and four paired leaf suckers. The soft rot incidence was recorded by observing 100 plants. Percent disease incidence (DI) was determined using the formula:

Disease Incidence = (Number of infected plants / Total number of plants observed) x 100

Statistical analysis

The analysis of variance was done in randomized block design for various observations observed during experiment by using statistical software SAS 9.2 (Anon 2008). DMRT comparisons among the essential oil, compounds obtained from the germplasm including check and between the harvesting stages. The results were presented at 5% level of significance (P = 0.05). The critical difference (CD) values were calculated to compare the various treatment means.

RESULTS AND DISCUSSION

The performance of different yield contributing parameters with sucker types at different harvesting periods were observed in the present study (Table 1). Seven months after transplanting of suckers with four paired leaves had maximum survival (98.64%), plant height (57.20 cm), plant spread (1834.75 cm^2), number of mature leaves per plant (9.60), weight per plant (2.93 kg), weight of leaves per plant (2.76 kg), leaf length (50.76 cm), leaf width (5.74 cm), leaf diameter (13.97 mm), number of spines (20.60), weight of roots (99.33 g), number of roots (50.33) and root length (25.77 cm) followed by suckers with three paired leaves (89.23%, 49.81 cm, 1305.99 cm^2, 7.45, 2.01 kg, 1.94 kg, 41.56 cm, 4.80 cm, 12.31 mm, 18.60, 57.60 g, 37.80 and 23.62 cm), respectively. The maximum number of fresh leaves per plant and root diameter was observed in suckers with three paired leaves (3.31 and 2.65 mm, respectively) followed by suckers with two paired leaves (3.24 and 2.56, respectively). While the minimum survival (58.1%), plant height (39.56 cm), plant spread (656.20 cm^2), number of mature leaves per plant (5.82), weight of plant (0.37 kg), weight of leaves (0.35 kg), leaf length (33.78 cm), leaf width (3.02 cm), leaf diameter (10.31 mm), weight of roots (16.20 g), number of roots (21), root length (19.33 cm) and root diameter (1.76 mm) were found in suckers with one paired leaves and the minimum number of fresh leaves per plant (2.80) and number of spines (14.60) were observed in suckers with four paired and two paired leaves, respectively.

After eight months of transplanting suckers with four paired leaves had maximum survival (98.30%), plant height (71.53 cm), plant spread (2484 cm^2), number of mature leaves per plant (11.67), weight of plant (4.44 kg), weight of leaves (4.37 kg), leaf length (54.76 cm), leaf width (5.97 cm), leaf diameter (15.86 mm), number of spines (24), weight of roots (70 g), number of roots (40.67), root length (15.40 cm) and root diameter (3.28 mm) followed by suckers with three paired leaves for survival (85.37%), plant height (63.63 cm), plant spread (2061.90 cm^2), number of mature leaves per plant (8.67), weight of plant (2.39 kg), weight of leaves (2.34 kg), leaf length (50.60 cm), leaf diameter (14.06 mm), number of spines (21), weight of roots (51.33 g), number of roots (35.33) and root length (15.07 cm)and suckers with two paired leaves for leaf width (5 cm), root diameter (3.08 mm). The maximum number of fresh leaves per plant (3.00) was observed in suckers with three and two paired leaves, respectively, followed by suckers with four and one paired leaves (2.67). The minimum survival (57.14%), plant height (46.43 cm), plant spread (743.67 cm^2), number of mature leaves per plant (6.67), weight of plant (0.73 kg), weight of leaves (0.71 kg), leaf length (40.67 cm), leaf width (3.97 cm), leaf diameter (11.67 mm), number of spines (18), weight of roots (26 g), number of roots (31.67), root length (13.70 cm) and root diameter (2.82 mm) were observed in suckers with one paired leaves.

After nine months of transplanting suckers with four paired leaves had maximum survival (97.96%), plant height (72.33 cm), plant spread (2463 cm^2), number of mature leaves per plant (12), weight of plant (4.73 kg), weight of leaves (3.99 kg), leaf length (80.18 cm), leaf width (8.83 cm), leaf diameter (24.54 mm), number of spines (35.38), weight of roots (73 g), number of roots (42.39), root length (17.73 cm) and root diameter (3.42 mm) followed by suckers with three paired leaves (83.67%, 57.50 cm, 1983.33 cm^2, 9.00, 3.05 kg, 3.20 kg, 70.89 cm, 8.37 cm, 23.09 mm, 32.60, 54.33 g, 37.64, 17.67 cm and 3.34 mm), respectively. The maximum number of fresh leaves per plant (3.33) was observed in suckers with three and two paired leaves, respectively followed by suckers with four paired leaves (3.00). The minimum survival (56.46%), plant height (43.83 cm), plant spread (1279 cm^2), number of mature leaves per plant (7), weight of plant (0.69 kg), weight of leaves (0.70 kg), leaf length (40.71 cm), leaf width (4.33 cm), leaf diameter (12.39 mm), number of spines

(19.58), weight of roots (29 g), number of roots (32.06), root length (15.34 cm) and root diameter (2.86 mm) were observed in suckers with one paired leaves. The plant height, number of tillers per plant, leaf length and number of leaves per plant increased with an increase in the harvesting period as observed in *Pennisetum pedicellatum* Trin. under Ethiopian condition (Asmare *et al.,* 4). In forage turnip (*Brassica rapa* L.) root length, root diameter, root yield and leaf yield increased with delay in harvesting time (Tiryakioglu and Turk, 18).

The performance of sucker's development for different sucker types at different harvesting period showed that after seven months of transplanting the suckers with four paired leaves had maximum number of suckers (6), length of sucker (29.87 cm), weight of sucker (943.67 g) and number of leaves per sucker (5.44) followed by suckers with three paired leaves (4.40, 25.18 cm, 597 g and 5.18, respectively).The maximum diameter of suckers (2.73 mm) was observed in suckers with three paired leaves followed by suckers with four paired leaves (2.59 mm). While the minimum numbers of suckers (1.25), length of sucker (12.41 cm), weight of sucker (19.50 g), diameter of suckers (1.30 mm) and number of leaves per sucker (3.40). After eight months of transplanting the suckers with four paired leaves had maximum number of suckers (8.33), length of sucker (35.52 cm), weight of sucker (278.92 g), diameter of suckers (9.52 mm) and number of leaves per sucker (7) followed by suckers with three paired leaves (Fig. 1). The minimum numbers of suckers (2), length of sucker (15.43 cm), weight of sucker (36.83 g), diameter of suckers (5.45 mm) and number of leaves per sucker (3.90) were observed in suckers with one paired leaf. With the increase of harvesting duration for plant growth was also increased with effective use of environmental factors which resulted in increase of plant height, leaf length, leaf diameter, number of leaves and leaves weight in *Aloe barbadensis* Miller (Hazrati *et al.,* 11). Over all the crop (mature leaves) and suckers were started harvesting regularly at seven, eight and nine months after transplanting. However, Aloe vera crop is ready to harvest after 18 months of sowing (Cristiano *et al.,* 6; Das and Chattopadhay, 8; Rajeswari *et al.,* 15).

Table 1. Performance of different yield contributing parameters at different harvesting period and sucker types.

Sucker size/Harvesting period	Survival (%)	Plant height (cm)	Average spread (cm^2)	No. of fresh leaves/ plant	No. of mature leaves/ plant	Plant weight (kg)	Leaves weight (kg)	Leaf length (cm)	Leaf width (cm)	Leaf diameter (mm)	No. of spines/ leaf	Root weight/ plant (g)	No. of roots/plant	Root length (cm)	Root diameter (mm)
Seven months after transplanting															
One pair leaf	58.16^{d}	39.56^{d}	656.20^{d}	3.20^{c}	5.82^{d}	0.37^{d}	0.35^{c}	33.78^{d}	3.02^{cd}	10.31^{c}	14.80^{c}	16.20^{d}	21.00^{c}	19.33^{bc}	1.76^{c}
Two pairs leaves	82.88^{c}	44.70^{c}	935.36^{c}	3.24^{b}	6.42^{c}	1.38^{c}	1.28^{b}	36.66^{c}	3.72^{c}	10.97^{c}	14.60^{c}	53.60^{c}	37.60^{b}	20.64^{b}	2.56^{ab}
Three pairs leaves	89.23^{b}	49.81^{b}	1305.99^{b}	3.31^{a}	7.45^{b}	2.01^{b}	1.94^{ab}	41.56^{b}	4.80^{b}	12.31^{b}	18.60^{b}	57.60^{b}	37.80^{b}	23.62^{ab}	2.65^{a}
Four pairs leaves	98.64^{a}	57.20^{a}	1834.75^{a}	2.80^{d}	9.60^{a}	2.93^{a}	2.76^{a}	50.76^{a}	5.74^{a}	13.97^{a}	20.60^{a}	99.33^{a}	50.33^{a}	25.77^{a}	2.52^{b}
Eight months after transplanting															
One pair leaf	57.14^{d}	46.43^{d}	743.67^{d}	2.67^{b}	6.67^{c}	0.73^{d}	0.71^{d}	40.67^{c}	3.97^{c}	11.67^{d}	18.00^{bc}	26.00^{d}	31.67^{c}	13.70^{bc}	2.82^{b}
Two pairs leaves	73.47^{c}	58.73^{c}	1475.58^{c}	3.00^{a}	7.67^{bc}	1.77^{c}	1.73^{c}	49.02^{bc}	5.00^{b}	13.19^{c}	20.00^{b}	33.67^{c}	30.33^{bc}	14.73^{b}	3.08^{ab}
Three pairs leaves	85.37^{b}	63.63^{b}	2061.90^{b}	3.00^{a}	8.67^{b}	2.39^{b}	2.34^{b}	50.60^{b}	5.80^{ab}	14.06^{b}	21.00^{ab}	51.33^{b}	35.33^{b}	15.07^{ab}	2.83^{b}
Four pairs leaves	98.30^{a}	71.53^{a}	2484.00^{a}	2.67^{b}	11.67^{a}	4.44^{a}	4.37^{a}	54.76^{a}	5.97^{a}	15.86^{a}	24.00^{a}	70.00^{a}	40.67^{a}	15.40^{a}	3.28^{a}
Nine months after transplanting															
One pair leaf	56.46^{d}	43.83^{c}	1279.00^{d}	2.67^{b}	7.00^{c}	0.69^{d}	0.70^{d}	41.71^{c}	4.33^{c}	12.39^{c}	19.58^{d}	29.00^{d}	32.06^{c}	15.34^{b}	2.86^{b}
Two pairs leaves	70.41^{c}	52.80^{bc}	1588.02^{c}	3.33^{a}	8.00^{bc}	2.71^{c}	2.64^{c}	67.26^{bc}	7.88^{b}	20.72^{b}	28.40^{c}	36.67^{c}	33.24^{c}	16.15^{b}	3.04^{ab}

Three pairs leaves	83.67^{b}	57.50^{b}	1983.33^{b}	3.33^{a}	9.00^{b}	3.05^{bc}	3.20^{b}	70.89^{b}	8.37^{ab}	23.09^{ab}	32.60^{bc}	54.33^{b}	37.64^{bc}	17.67^{a}	3.34^{a}
Four pairs leaves	97.96^{a}	72.33^{a}	2463.64^{a}	3.00^{ab}	12.00^{a}	4.73^{a}	3.99^{a}	80.18^{a}	8.83^{a}	24.54^{a}	35.38^{a}	73.00^{a}	42.39^{a}	17.73^{a}	3.42^{a}

Means with the same letter (superscript) in the columns do not showing significantly different (P = 0.05) – (Duncan Multiple Range Test).

Table 2. Performance of sucker's development at different harvesting period and sucker types.

Sucker size/Harvesting period	No. of suckers/plant	Length of sucker (cm)	Weight of sucker (gm)	Diameter of suckers (mm)	No. of leaves/suckers
Seven months after transplanting					
One pair leaf	1.25^{c}	12.41^{c}	19.50^{d}	1.30^{d}	3.40^{c}
Two pairs leaves	3.60^{b}	22.33^{bc}	247.00^{c}	2.44^{c}	4.72^{b}
Three pairs leaves	4.40^{ab}	25.18^{ab}	597.00^{b}	2.73^{a}	5.18^{ab}
Four pairs leaves	6.00^{a}	29.87^{a}	943.67^{a}	2.59^{b}	5.44^{a}
Eight months after transplanting					
One pair leaf	2.00^{d}	15.43^{c}	36.83^{d}	5.45^{c}	3.90^{c}
Two pairs leaves	6.00^{c}	27.53^{b}	125.48^{c}	7.74^{b}	5.41^{bc}
Three pairs leaves	7.00^{b}	28.93^{b}	199.62^{b}	7.51^{b}	6.00^{b}
Four pairs leaves	8.33^{a}	35.52^{a}	278.92^{a}	9.52^{a}	7.00^{a}
Nine months after transplanting					
One pair leaf	1.86^{c}	15.58^{c}	37.33^{d}	5.59^{c}	3.73^{d}
Two pairs leaves	7.45^{b}	40.78^{b}	186.29^{c}	10.63^{b}	4.11^{c}
Three pairs leaves	9.70^{ab}	44.60^{ab}	305.96^{b}	11.24^{ab}	6.73^{b}
Four pairs leaves	10.32^{a}	45.29^{a}	354.23^{a}	12.39^{s}	7.11^{a}

Means with the same letter (superscript) in the columns do not showing significantly different (P = 0.05) – (Duncan Multiple Range Test).

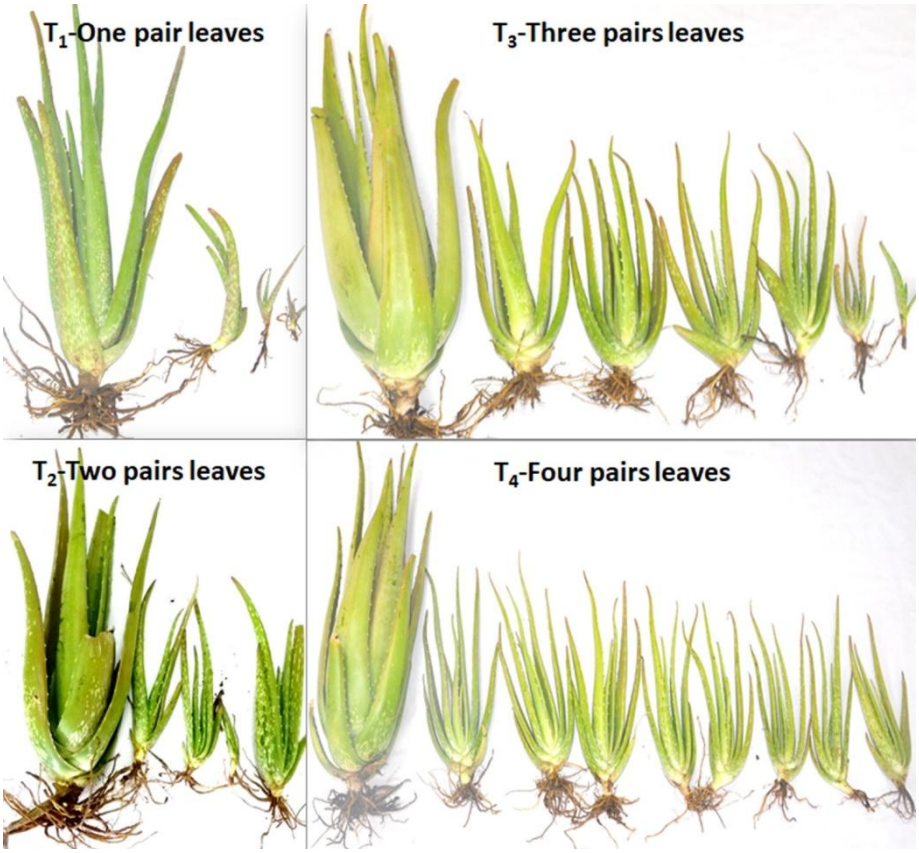

Fig. 1. Number of suckers produced at eight months after transplanting by different sucker types used for plantation.

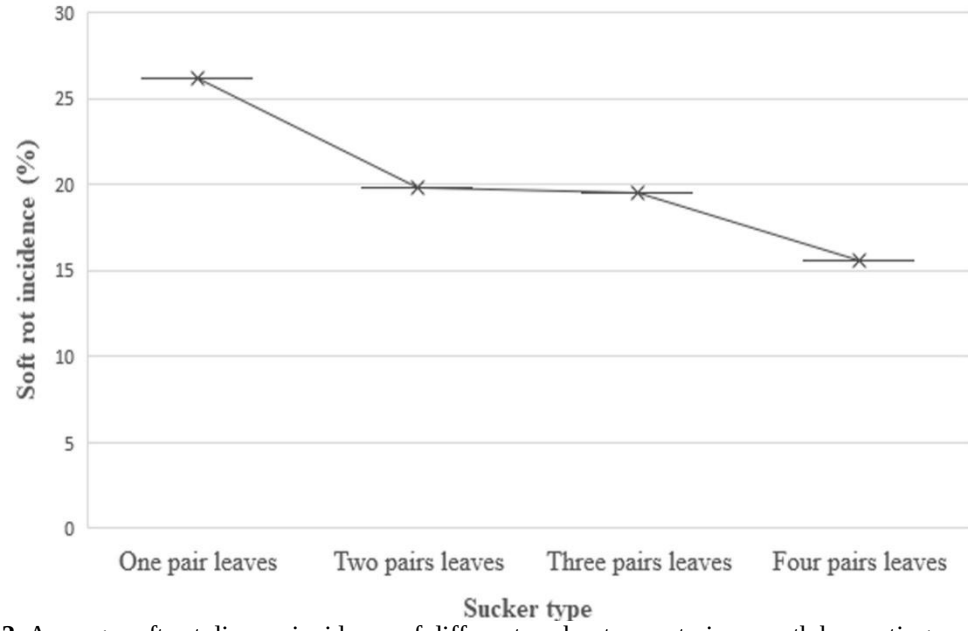

Fig. 2. Average soft rot disease incidence of different sucker types at nine month harvesting period.

Fig. 3. Soft rot disease incidence in one pair and two pair leaf suckers transplanted in field at nine month harvesting period (rainy season).

After nine months of transplanting the suckers with four paired leaves had maximum number of suckers (10.32), length of sucker (45.29 cm), weight of sucker (354.23 g), diameter of suckers (12.39 mm) and number of leaves per sucker (7.11) followed by suckers with three paired leaves (9.70, 44.60 cm, 305.96 g, 11.24 mm and 6.73, respectively). The minimum numbers of suckers (1.86), length of sucker (15.58 cm), weight of sucker (37.33 g), diameter of suckers (5.59 mm) and number of leaves

per sucker (3.73) were observed in suckers with one paired leaf. In "Sugarloaf" pineapple the plant height, number of leaves per plant, slip number per plant, crown weight and crown length were found maximum in large sized suckers (Norman, 13). In Chrysanthemum, large sized suckers and delayed harvesting gave maximum number of flowers per plant, flower diameter and weight of flower (Anjum *et al.*, 3). At same time soft rot diseases symptoms were observed. The incidence of disease had negative relationship with increase sucker leaf pairs during ninth months of harvesting (Fig. 2). The disease incidence observed severely during the rainy season due to high moisture (Fig. 3). The incidence of disease observed ranging from 15 to 26% and varied in different leaf paired suckers, this might be due to poor plant development at early sucker types and nine-month coincidence with rainfall (Mandal and Maiti. 12). The role of free water and anaerobiosis weakening the host resistance in potato (Perombelon, 14).

Quality planting material production of Aloe vera play important role than leaf production due to dependence. The global market demand curve rising with continually for Aloe vera produce, therefore, there is a need for suitable propagation technique for faster multiplication with higher leaf production. Maximum leaf and sucker were also observed in three and four pairs leaves at nine months after transplanting. The leaf and sucker yield were increased with increase the sucker sizes.

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