# Seasonal changes in respiratory rates of cultivated cuttings of *Cryptomeria japonica* after root initiation.

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**Summary** The respiratory rates ($mgCO_2$/g dry weight/hour at 25°C) are used as data when we estimate the amount of respiration. In this experiment, the respiratory rates of cuttings of *Cryptomeria japonica* were measured at intervals of one month during about two years from immediately after root initiation. The rates of individual and six sections, such as zero year old leaf, one year old leaf, two years old leaf, terrestrial-stem, subterranean-stem (inserted stem under the ground for cutting) and root were measured.

The respiratory rates, in both case of individual and sections, showed the tendencies to increase rapidly in spring and fall, and to decrease gradually from spring to summer and from fall to winter (see Figure 1, 2 and 5.), too. However only the rates of root somewhat differed from these tendencies, its respiratory rates showed the tendencies to increase also in winter and to increase regularly at intervals of five months (see Figure 6.).

It is considered that these seasonal changes in respiratory rates were influenced considerably by the rise and fall of periodic physiological activity, seeing that growing season of *Cryptomeria japonica* exists in spring and fall. And it is supposed as one reason that the rates of fall observed relatively high values were affected by the strong irradiation of sunlight because sun-shade was taken off September.

The respiratory rates of leaf decreased with the lapse of time, namely, with the lapse of leaf-age. For this reason, it is estimated that physiological activity of leaf falls every year. When leaf passes for four to five years in the future, it is supposed that the rates of leaf do not depend on seasonal periodicity, and leaves live only basic metabolism at various temperatures, or defoliate. It is considered that the gradual decrement in respiratory rates from fall to winter depends on the temperature, on the other hand, the gradual decrement from spring to summer is due to a series of dry matter production without accompanied by respiratory substances. Because, when dry matter production continues without accompanied by increment of respiratory substances, or respiratory activity, if the respiratory rates are given by ' per unit dry matter weight ', then the rates are indicated necessarily by the tendency of decrement. But it is supposed that just before beginning of growth, respiratory substances are increased and activated by the changes and the translocations of material, seeing that the rates increase rapidly in spring and fall. And if the respiratory rates are compared leaf and terrestrial-stem (above the ground) with subterranean-stem and root (under the ground), then it is recognized that the seasonal changes in the respiratory rates are slightly different. Therefore, it is estimated that respiratory substances translocate the interior of plant.

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The respiratory rates of individual and those of total section did not agree. The rates of total section were extremely high values than those of individual. It is considered that in each section, large amounts of $CO_2$ were released by the excision of plant organs.

When we discuss from the standpoint of income and outgo on the dry matter production in plant community, as a procedure for this purpose, we must know the amount of respiration. As one method, we can calculate the amount of respiration from respiratory rate. The purpose of this experiment is to investigate on the respiratory rate in more detail that used as basic data for estimation of the amount of respiration. Therefore, seasonal changes in respiratory rates are discussed with the consideration on the translocation of respiratory substances in this paper.

In this experiment, the cultivated cuttings of *Cryptomeria japonica* immediately after root initiation are used during about two years. There are several literatures [1, 2, 8, 10, 11] about respiration or translocation from cutting to root initiation, but no literature about respiration after root initiation. From this point of view, it is interesting to discuss on the respiratory rate after root initiation.

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## Material and Methods

Mother trees are young *Cryptcmeria jatonica* (oscalled Hizumo Sugi), living in Okumyogata Village, Gifu Prefecture. Cuttings were collected from this stand on April 3 and 4, 1967. The following day, they were brought to Kyoto, and directly were immersed in running water. The condition of cuttings are given in Table 1. The measurement of respiratory rate was started from June, 1967, when root initiation was recognized. Then, the respiratory rates were measured at intervals of one month a period of seventeen months until November, 1968.

Procedures of measurement are as follows: (1) every one month, five to seven cultivated cuttings are dug out carefully, and the soil adhering to root is washed off with water, (2) samples are placed beforehand under the constant temperature (25°C) for half-hour,

Table 1 Conditions of cutting

| | |
|---|---|
| Length | 30cm |
| Diameter of cut base | 6.5±0.5mm |
| Shape of cut base | cutback |
| Inserted depth under the ground | 10cm |
| Mean dry weight per cutting | 13.4g |
| Total number of cutting | 120 |
| Density of cutting | 230 number/m² |
| Soil of cutting bed | B to C horizon of brown forest soil (socalled red soil) |
| Date and place of cutting | April 18, 1967, in the glazed house |

(3) then, mean respiratory rate ($mgCO_2$/g dry weight/hour at 25°C) of individual is measured to make use of infrared gas analyser (URAS-Type I), (4) individual is separated six sections, such as zero year old leaf, one year olf leaf, two years old leaf, terrestrial-stem, subterranean-stem (inserted stem under the ground for cutting) and root, (5) mean respiratory rates per each section are measured with the same apparatus.

## Results and Discussion

Mean diameter growth of cuttings was too slowly. On the other hand, though mean height growth was slowly for the first one year, it became rapidly in the second year. Also mean dry weight growth was slowly in spring of growing season both the first and the second year. By the way, it became somewhat rapidly in fall. The amount of dry weight growth was not supplied by old tissues (old leaves and subterranean-stem), but was almost supplied by new tissues (new leaves, root and new elongated part of terrestrial-stem).

1. Seasonal changes in respiratory rates of individual

The seasonal change in mean respiratory rates of the individual in each month is summarized in Figure 1. The rate shows relatively high value in June, 1967, beginning of measurement—namely immediately after root initiation. Then, the rates decrease until that it shows again relatively high value in October, 1967. Similarly, hereafter the rates decrease until that it indicates high value in April, 1968. The change observed after this is much the same as that observed in the previous year. In brief, respiratory rates show the tendencies to increase rapidly in spring and fall, and to decrease gradually from spring to summer and from fall to winter, too. It is considered that this seasonal change in respiratory rates is influenced considerably by the rise and fall of

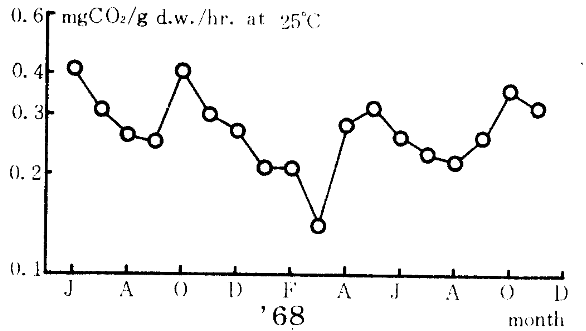


Fig. 1. Seasonal change in respiratory rate of the individual.

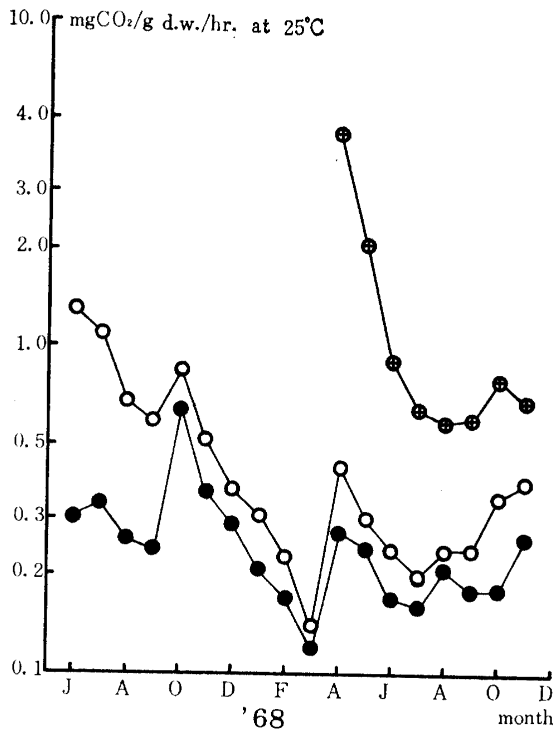


Fig. 2. Seasonal changes in respiratory rates of the three sections of leaf.

○: zero year old leaf, June, 1967. consequently one year old leaf from April, 1968.

●: one year old leaf, June, 1967. consequently two years old leaf from April, 1968.

⊕: zero year old leaf, April, 1968.

physiological activity, seeing that growing season of *Cryptomeria japonica* exists in spring and fall. And it is supposed as one reason that the rates of fall observed relatively high values are affected by the strong irradiation of sunlight because sun-shade is taken off September.

2. Seasonal changes in respiratory rates of leaf

The seasonal changes in respiratory rates of the three sections of leaf observed in each month are summarized in Figure 2. Since this experiment was started in June, 1967, the rates of one year old leaf (marked ●) indicate extremely low values for the first three to four months than that of zero year old leaf (marked ○). Subsequently, the rates of three leaves change roughly parallel. The changes in respiratory rates of the mentioned above are almost the same as that observed at the individual. In brief, respiratory rates show the tendencies to increase rapidly in spring and fall, and to decrease gradually from spring to summer and from fall to winter, too. And it is known that respiration increases rapidly at leaf developing period, seeing that the respiratory rate of zero year old leaf (marked ⊕) observed in April, 1968, is 4.53 $mgCO_2$/g d.w./hr. at 25°C. The seasonal change and aging in respiratory rates of the leaf are summarized in Figure 3. In this Figure, the axis of abscissa show leaf-age (time). The three sections of leaf indicated in Figure 2 are slid across by leaf-age. What is evident from this Figure is that the rates of leaf decrease with the lapse of time. Also, the rates of increment of respiration in spring and fall go down lower with the lapse of time. These results have been pointed out by Nakai, T.[6], Shiroya et al[12] and Kusumoto, T.[3] For the reason, it is considered that physiological activity of leaf is declined by aging with the lapse of time. When leaf passes for four to five years in the future, it is supposed that respiratory rates do not depend on seasonal periodicity, and leaves live only basic metabolism at various temperatures, or defoliate. In Figure 4, the axis of abscissa show monthly mean temperature, and the respiratory rates measured at 25°C are converted the rates at mean temperature of each month by $Q_{10}=2$. Generally, decrement of the rates from spring to summer are showed by the right down inclination, on the other hand, decrement of the rates from fall to winter are showed by the left down inclination. Respiration depends on temperature primarily. From this reason, it is supposed that the rates from fall to winter depend on temperature. But clearly the rates from spring to summer do not depend on temperature. In this period (from spring to summer), the plants grow vigorously by means of photosynthesis as being pointed out by Shiroya et al[12]. After all, it is supposed that dry matter production are continued till summer, on the contrary, respiratory substances are not increased or are not activated. Therefore, it is considered that if the respiratory rates are calculated by 'per unit dry matter weight', then the rates are indicated by the tendency of decrement till summer. But, seeing that the rates increase rapidly in spring and fall, it is supposed that just before beginning of growth, respiratory substances are increased and activated by the changes and the translocations of material.

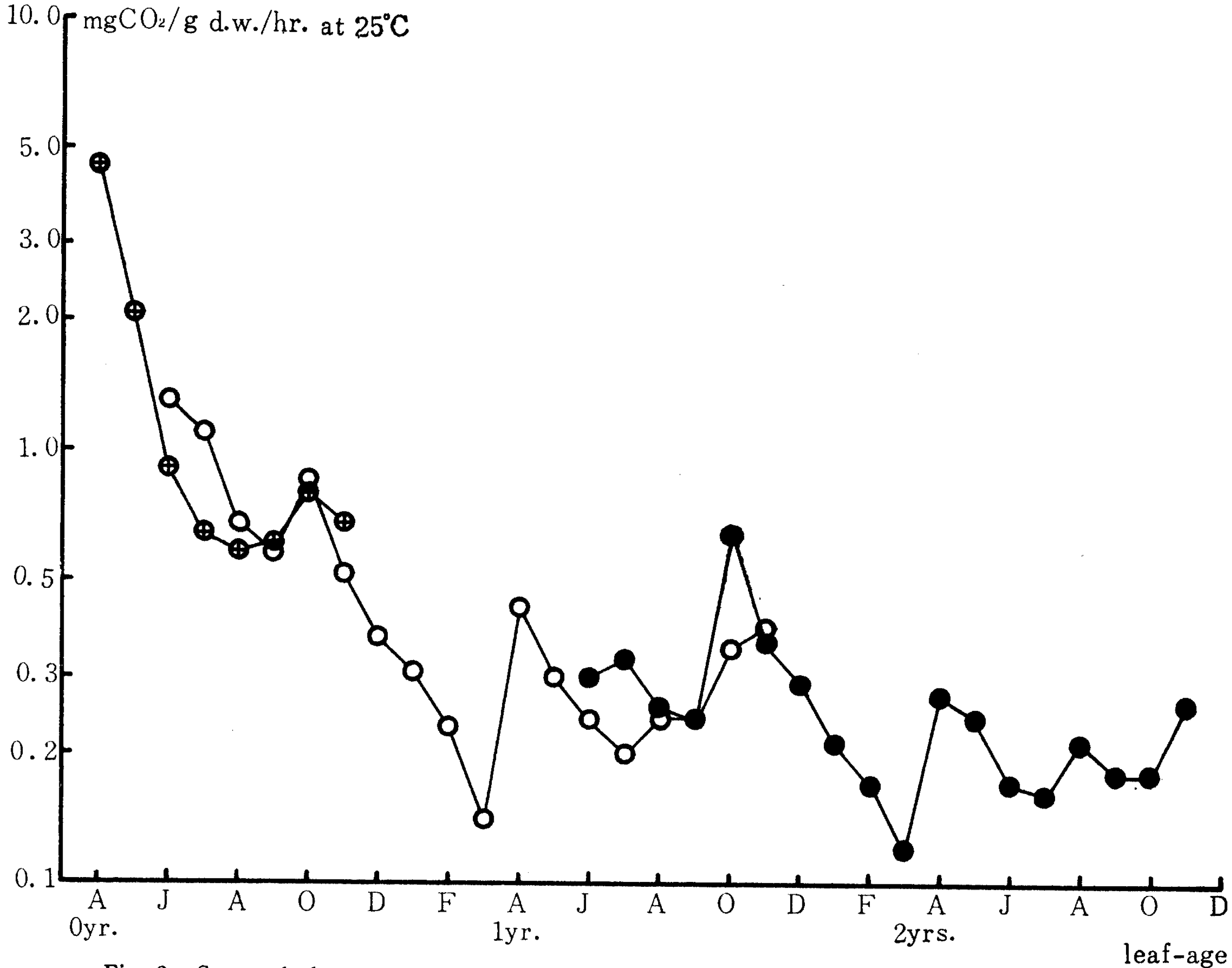


Fig. 3. Seasonal change and aging in respiratory rates of the leaf. Three sections of leaf indicated in Fig. 2. are slid across by leaf-age.

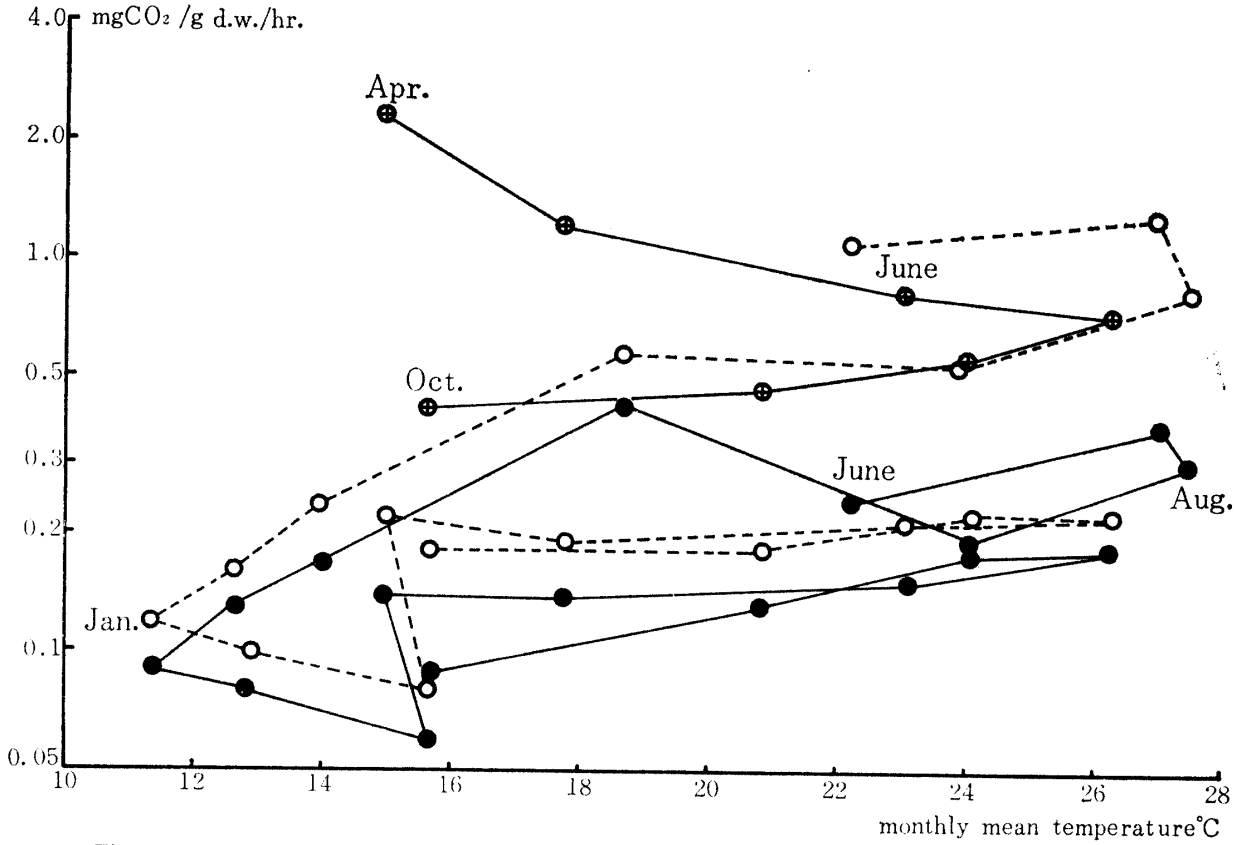


Fig. 4. Seasonal change in respiratory rates of the leaf at mean temperature of each month.

3. Seasonal changes in respiratory rates of terrestrial-stem

The seasonal change in respiratory rates of the terrestrial-stem observed in each month is summarized in Figure 5. Also, as is evident from this Figure, it is showed that the rates of terrestrial-stem increase rapidly in spring and fall, the same as that observed at the individual and the leaf. The rates of the second year show relatively high values than that of the first one year. It is supposed that natural branch are converted stem two years after cutting. Namely, from the second year, photosynthesis and respiration are activated vigorously for the height growth as the stem, and substances are producted and translocated actively. If the new elongated shoots (tip of terrestrial-stem) are separated from stem, then their respiratory rates are indicated the higher values, because essentially they are much the same as zero year old and one year old leaf.

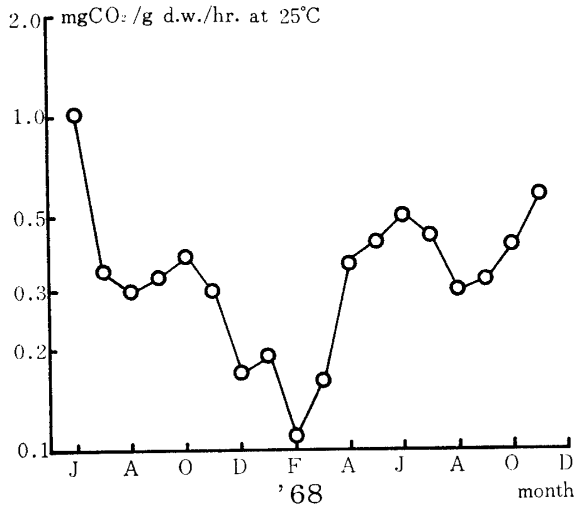


Fig. 5. Seasonal change in respiratory rate of the terrestrial-stem.

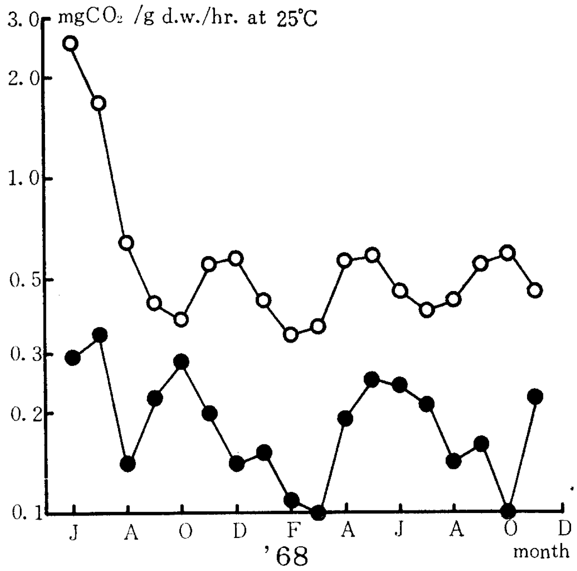


Fig. 6. Seasonal changes in respiratory rates of the subterranean parts.
○ : Root ● : Subterranean-stem

4. Seasonal changes in respiratory rates of subterranean parts

The seasonal changes in respiratory rates of the subterranean parts observed in each month are summarized in Figure 6. The rates of root indicate extremely high values immediately after root initiation. Thereafter, as root grows, namely as the degree of lignification increases, the rates decrease. But, the rates increase regularly in winter, spring and fall, at intervals of five months, after October, 1967. It is supposed that this regular change continues still more, because no lignificated root of total root occupies above fifty percent in November, 1968. If the rates of root are compared with that of leaf (see Figure 2.), then it is observed that in fall, the rates of root increase later than that of leaf. For this reason, it is supposed that respiratory substances translocate the interior of plant. Finally, it is considered as follows: respiratory responses to growth arise from aerial part, then respiratory substances are moved towards the leaf and shoot, or activated in the leaf and shoot, thereafter with the products based upon photosynthesis, respiratory substances translocate downwards, and they are activated in the subterranean parts. Still it is considered that in the first one year after cutting, the rates of root are influenced considerably by defective of subterranean parts.

The respiratory rates of subterranean-stem show relatively low values in six sections. Though the rates increase in spring and fall, it is supposed that subterranean-stem acts only parts as passage of substances. And it is considered that respiratory substances are moved towards the root, because the rates of root increase later than that of subterranean-stem.

**要旨**：呼吸量を知るうえで基礎的な資料となる呼吸速度($mgCO_2$/g dry weight/hour at 25°C) を，スギのさし木苗を用いて，発根直後から約2年間にわたり，1カ月間隔でもとめた。測定は個体と部分（0年生，1年生，2年生の各葉，主軸，地下主軸，根）にわけて行なった。

呼吸速度は個体，各部分のいずれについても，春と秋に急激に増加し，春から夏，秋から冬にかけて緩慢に減少した。しかし，根だけはこの傾向がやや異っており，5カ月の間隔をおいて規則的に呼吸速度の増減をくりかえし，冬にも呼吸速度の増加がみられた。

春と秋における呼吸速度の増加は，スギ苗の生長の盛んな時期が春と秋にあるという週期的な生理活性の消長が大きく影響をおよぼした結果であると考えられる。また，秋に比較的高い呼吸速度がみられたのは，日おいをはずしたことによる一時的な光の強い照射が1つの原因とも考えられる。

葉の呼吸速度は葉令が進むとともに減少しており，葉の生理活性が年々低下することが推察された。さらに葉令が4，5年とふえる場合には，呼吸速度は季節的な週期性に影響されず，温度依存による基礎代謝だけか，あるいは落葉するということが考えられる。

呼吸作用が本来，温度に依存することから，秋から冬への呼吸速度の減少は温度依存的な現象であると思われる。一方，春から夏へは，この期間で盛んに物質生産が行なわれており，物質の蓄積が続くが，呼吸基質は一定量を維持するわずかの増加しかないため，単位乾重あたりで呼吸速度をもとめた場合，物質生産が続くかぎり減少傾向となることが考えられる。しかし，週期の一環としての生長の開始直前では，何らかの作用により物質の変化，転流などがあって，呼吸基質の増加や活性化の起ることが予想される。

また，地下部分の呼吸速度が地上部分のそれよりも遅れて増加したり，季節変化に若干のちがいがあることから呼吸基質となる物質の苗体内での流れが考えられる。

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