In [4]:

```
import pandas as pd
```

In [5]:

```
df = pd.read_csv('blueberry_yield.csv')
```

In [6]:

```
df.head()
```

Out[6]:

	id	clonesize	honeybee	bumbles	andrena	osmia	MaxOfUpperTRange	MinOfUpperTRange	AverageOfUpperTRange	MaxOfLowerTRange
0	0	25.0	0.50	0.25	0.75	0.50	69.7	42.1	58.2	50.2
1	1	25.0	0.50	0.25	0.50	0.50	69.7	42.1	58.2	50.2
2	2	12.5	0.25	0.25	0.63	0.63	86.0	52.0	71.9	62.0
3	3	12.5	0.25	0.25	0.63	0.50	77.4	46.8	64.7	55.8
4	4	25.0	0.50	0.25	0.63	0.63	77.4	46.8	64.7	55.8

In [7]:

```
df.tail()
```

Out[7]:

	id	clonesize	honeybee	bumbles	andrena	osmia	MaxOfUpperTRange	MinOfUpperTRange	AverageOfUpperTRange	MaxOfLowe
15284	15284	12.5	0.25	0.25	0.38	0.50	77.4	46.8	64.7	
15285	15285	12.5	0.25	0.25	0.25	0.50	86.0	52.0	71.9	
15286	15286	25.0	0.50	0.25	0.38	0.75	77.4	46.8	64.7	
15287	15287	25.0	0.50	0.25	0.63	0.63	69.7	42.1	58.2	
15288	15288	25.0	0.50	0.25	0.63	0.50	77.4	46.8	64.7	

In [8]:

```
df.shape
```

Out[8]:

```
(15289, 18)
```

In [9]:

```
df.columns
```

Out[9]:

```
Index(['id', 'clonesize', 'honeybee', 'bumbles', 'andrena', 'osmia',
       'MaxOfUpperTRange', 'MinOfUpperTRange', 'AverageOfUpperTRange',
       'MaxOfLowerTRange', 'MinOfLowerTRange', 'AverageOfLowerTRange',
       'RainingDays', 'AverageRainingDays', 'fruitset', 'fruitmass', 'seeds',
       'yield'],
      dtype='object')
```

In [10]:

```
df.duplicated().sum()
```

Out[10]:

```
0
```

In [11]:

```
df.isnull().sum()
```

Out[11]:

```
id                      0
clonesize               0
honeybee                0
bumbles                 0
andrena                 0
osmia                   0
MaxOfUpperTRange        0
MinOfUpperTRange        0
AverageOfUpperTRange    0
MaxOfLowerTRange        0
MinOfLowerTRange        0
AverageOfLowerTRange    0
RainingDays             0
AverageRainingDays      0
fruitset                0
fruitmass               0
seeds                   0
yield                   0
dtype: int64
```

In [12]:

```
df = df.drop('id', axis = 1)
```

In [13]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 15289 entries, 0 to 15288
Data columns (total 17 columns):
 #   Column                Non-Null Count  Dtype  
---  ------                --------------  -----  
 0   clonesize             15289 non-null  float64
 1   honeybee              15289 non-null  float64
 2   bumbles               15289 non-null  float64
 3   andrena               15289 non-null  float64
 4   osmia                 15289 non-null  float64
 5   MaxOfUpperTRange      15289 non-null  float64
 6   MinOfUpperTRange      15289 non-null  float64
 7   AverageOfUpperTRange  15289 non-null  float64
 8   MaxOfLowerTRange      15289 non-null  float64
 9   MinOfLowerTRange      15289 non-null  float64
 10  AverageOfLowerTRange  15289 non-null  float64
 11  RainingDays           15289 non-null  float64
 12  AverageRainingDays    15289 non-null  float64
 13  fruitset              15289 non-null  float64
 14  fruitmass             15289 non-null  float64
 15  seeds                 15289 non-null  float64
 16  yield                 15289 non-null  float64
dtypes: float64(17)
memory usage: 2.0 MB
```

In [14]:

```
df.describe()
```

Out[14]:

	clonesize	honeybee	bumbles	andrena	osmia	MaxOfUpperTRange	MinOfUpperTRange	AverageOfUpperTRar
count	15289.000000	15289.000000	15289.000000	15289.000000	15289.000000	15289.000000	15289.000000	15289.000
mean	19.704690	0.389314	0.286768	0.492675	0.592355	82.169887	49.673281	68.656
std	6.595211	0.361643	0.059917	0.148115	0.139489	9.146703	5.546405	7.641
min	10.000000	0.000000	0.000000	0.000000	0.000000	69.700000	39.000000	58.200
25%	12.500000	0.250000	0.250000	0.380000	0.500000	77.400000	46.800000	64.700
50%	25.000000	0.500000	0.250000	0.500000	0.630000	86.000000	52.000000	71.900
75%	25.000000	0.500000	0.380000	0.630000	0.750000	86.000000	52.000000	71.900
max	40.000000	18.430000	0.585000	0.750000	0.750000	94.600000	57.200000	79.000

In [15]:

```
df.nunique()
```

Out[15]:

```
clonesize                  6
honeybee                   7
bumbles                   11
andrena                   16
osmia                     14
MaxOfUpperTRange           6
MinOfUpperTRange           5
AverageOfUpperTRange       5
MaxOfLowerTRange           6
MinOfLowerTRange           7
AverageOfLowerTRange       5
RainingDays                6
AverageRainingDays         8
fruitset                1525
fruitmass               1515
seeds                   2066
yield                    776
dtype: int64
```

In [16]:

```
import matplotlib.pyplot as plt
import seaborn as sns
```

In [17]:

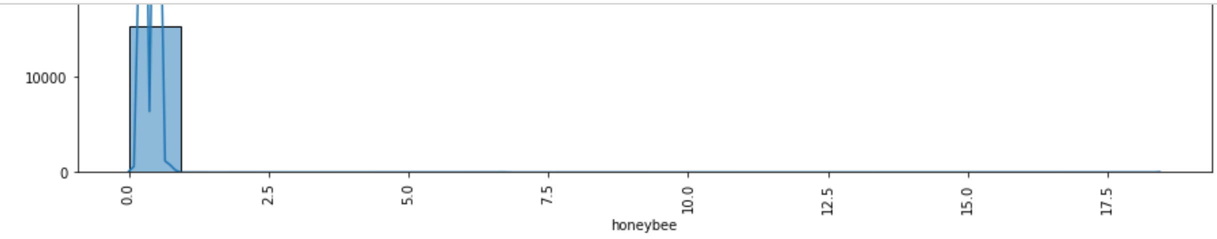
```
import numpy as np
```

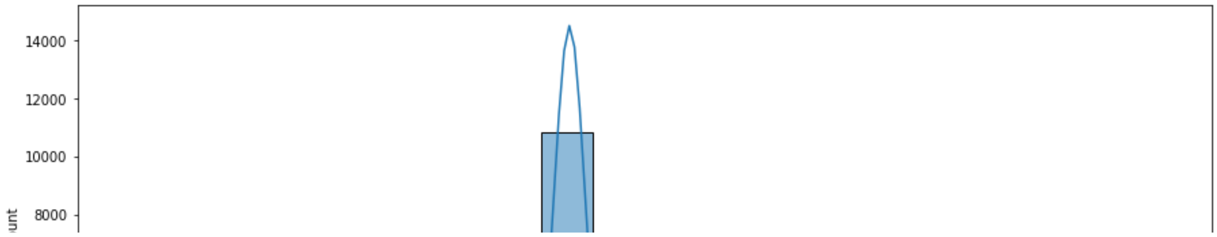
In [18]:

```
import warnings
warnings.filterwarnings('ignore')
```

In [19]:

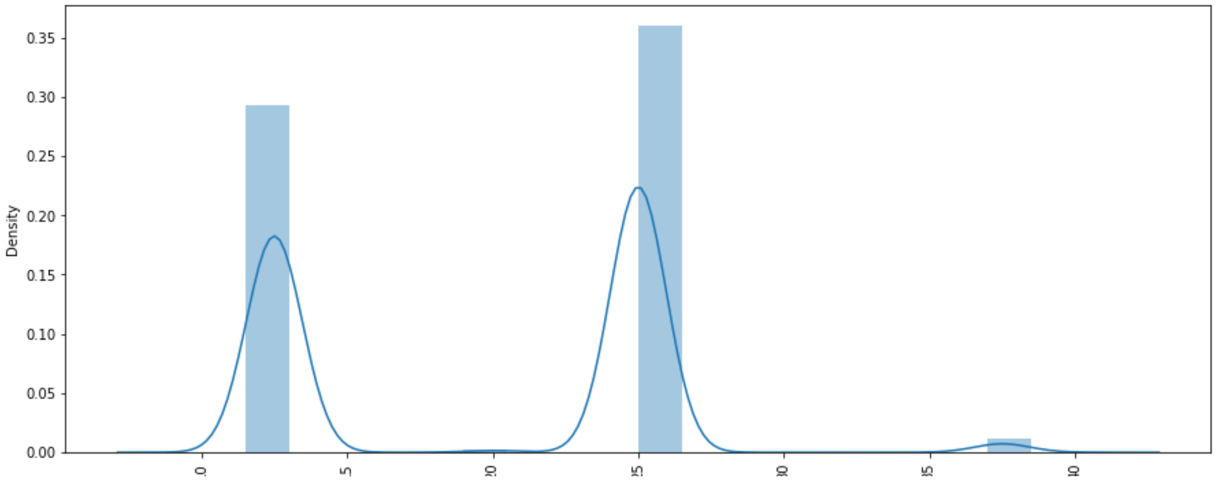
```
for i in df.columns:
    plt.figure(figsize=(15,6))
    sns.histplot(df[i], kde = True, bins = 20, palette = 'hls')
    plt.xticks(rotation = 90)
    plt.show()
```





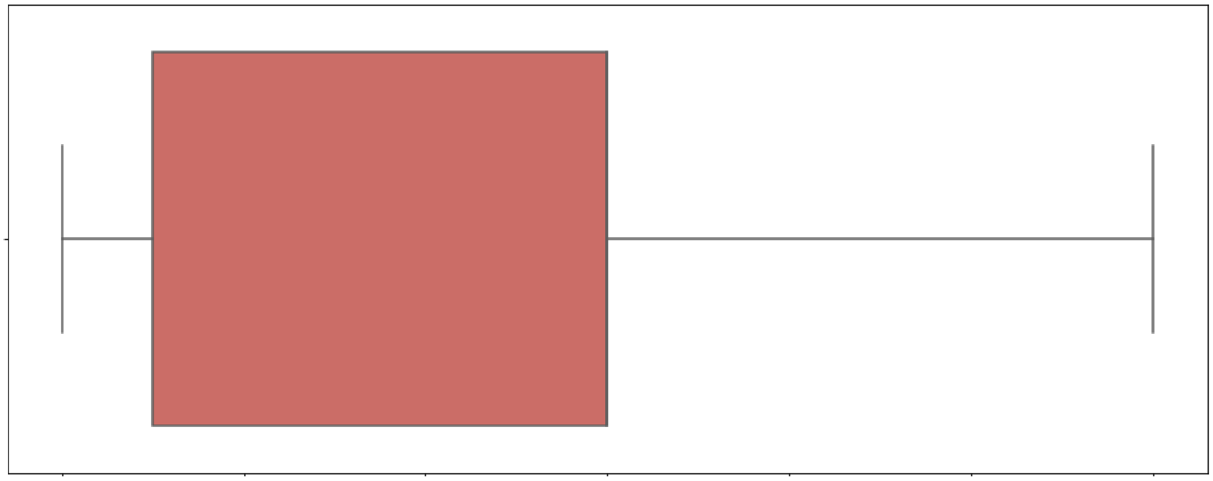
In [20]:

```
for i in df.columns:
    plt.figure(figsize=(15,6))
    sns.distplot(df[i], kde = True, bins = 20)
    plt.xticks(rotation = 90)
    plt.show()
```



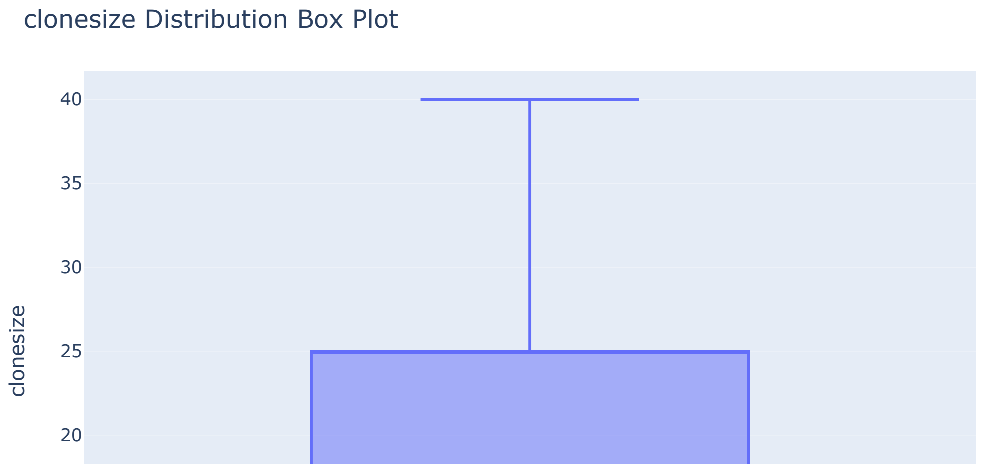
In [21]:

```
for i in df.columns:
    plt.figure(figsize=(15,6))
    sns.boxplot(df[i], data = df, palette = 'hls')
    plt.xticks(rotation = 90)
    plt.show()
```



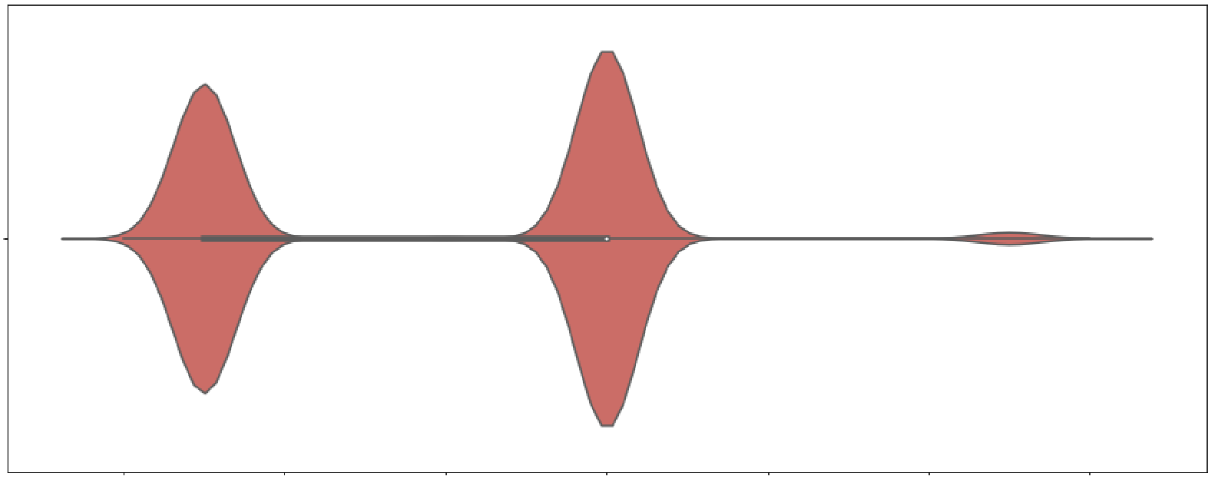
In [45]:

```
for i in df.columns:
    fig = px.box(df, y=i)
    fig.update_layout(title=i + ' Distribution Box Plot', xaxis_title=i)
    fig.show()
```



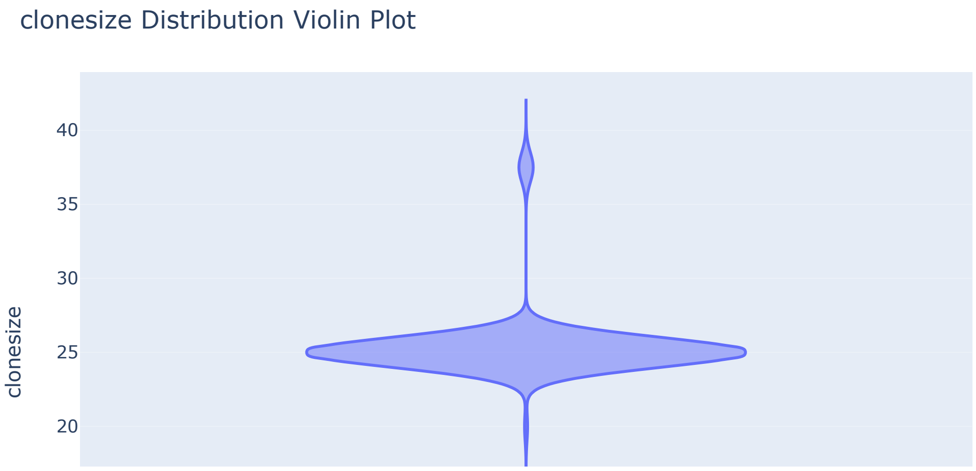
In [22]:

```
for i in df.columns:
    plt.figure(figsize=(15,6))
    sns.violinplot(df[i], data = df, palette = 'hls')
    plt.xticks(rotation = 90)
    plt.show()
```



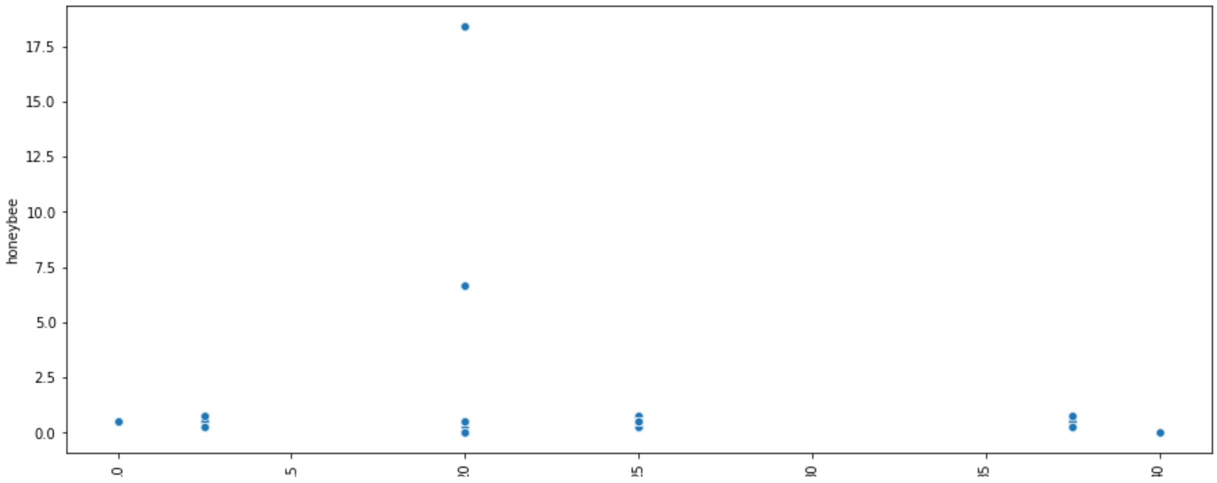
In [46]:

```
for i in df.columns:
    fig = px.violin(df, y=i)
    fig.update_layout(title=i + ' Distribution Violin Plot', xaxis_title=i)
    fig.show()
```



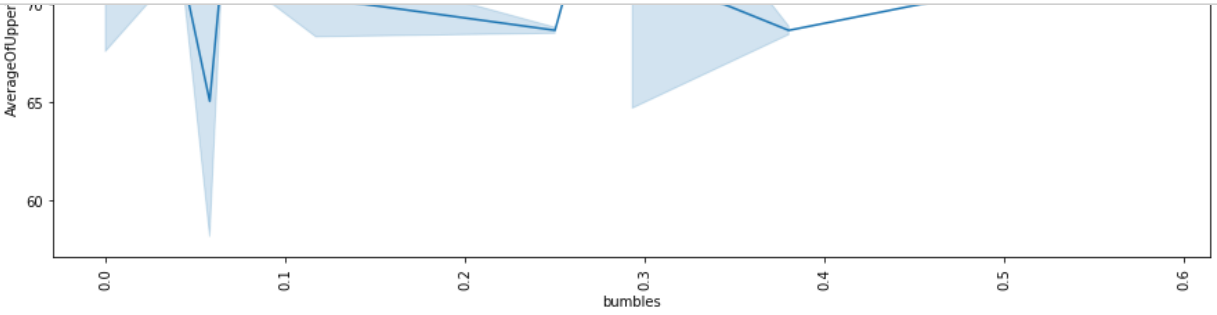
In [24]:

```
for i in df.columns:
    for j in df.columns:
        if i != j:
            plt.figure(figsize=(15,6))
            sns.scatterplot(x=i, y=j, data=df, palette='hls')
            plt.xticks(rotation=90)
            plt.show()
```



In [25]:

```
for i in df.columns:
    for j in df.columns:
        if i != j:
            plt.figure(figsize=(15,6))
            sns.lineplot(x=i, y=j, data=df, palette='hls')
            plt.xticks(rotation=90)
            plt.show()
```



In [26]:

```
df1 = df[['clonesize', 'honeybee', 'bumbles', 'andrena', 'osmia','MaxOfUpperTRange', 'MinOfUpperTRange', 'AverageOfUpperTRange
        'MaxOfLowerTRange', 'MinOfLowerTRange', 'AverageOfLowerTRange','RainingDays', 'AverageRainingDays']]
```

In [27]:

```
for i in df1.columns:
    print(i, ':')
    print(df1[i].unique())
    print('\n')
```

```
clonesize :
[25.  12.5 37.5 20.  10.  40. ]


honeybee :
[ 0.5    0.25   0.75   0.537  0.    18.43   6.64 ]


bumbles :
[0.25  0.38  0.117 0.058 0.56  0.065 0.    0.585 0.042 0.293 0.26 ]


andrena :
[0.75  0.5   0.63  0.38  0.25  0.409 0.707 0.    0.24  0.56  0.101 0.49
 0.234 0.147 0.235 0.229]


osmia :
[0.5   0.63  0.75  0.25  0.38  0.058 0.117 0.62  0.585 0.    0.021 0.02
 0.078 0.606]


MaxOfUpperTRange :
[69.7 86.  77.4 94.6 89.  79. ]


MinOfUpperTRange :
[42.1 52.  46.8 57.2 39. ]


AverageOfUpperTRange :
[58.2 71.9 64.7 79.  65.6]


MaxOfLowerTRange :
[50.2 62.  55.8 68.2 66.  52. ]


MinOfLowerTRange :
[24.3 30.  27.  33.  28.  25.  31. ]


AverageOfLowerTRange :
[41.2 50.8 45.8 55.9 45.3]


RainingDays :
[24.   34.    1.   16.    3.77 26.  ]


AverageRainingDays :
[0.39 0.56 0.1  0.26 0.06 0.25 0.07 0.14]
```

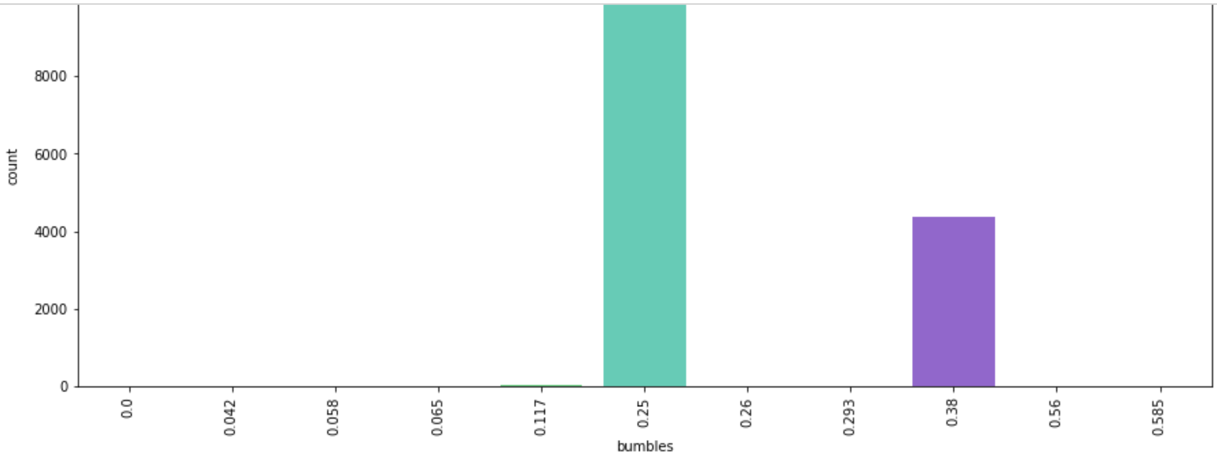
In [28]:

```
for i in df1.columns:
    print(i, ':')
    print(df1[i].value_counts())
    print('\n')
```

```
clonesize :
25.0    8245
12.5    6717
37.5     265
20.0      56
10.0       4
40.0       2
Name: clonesize, dtype: int64


honeybee :
0.500     7832
0.250     7285
0.750      110
0.537       38
0.000       16
18.430       5
6.640        3
Name: honeybee, dtype: int64
```

In [30]:

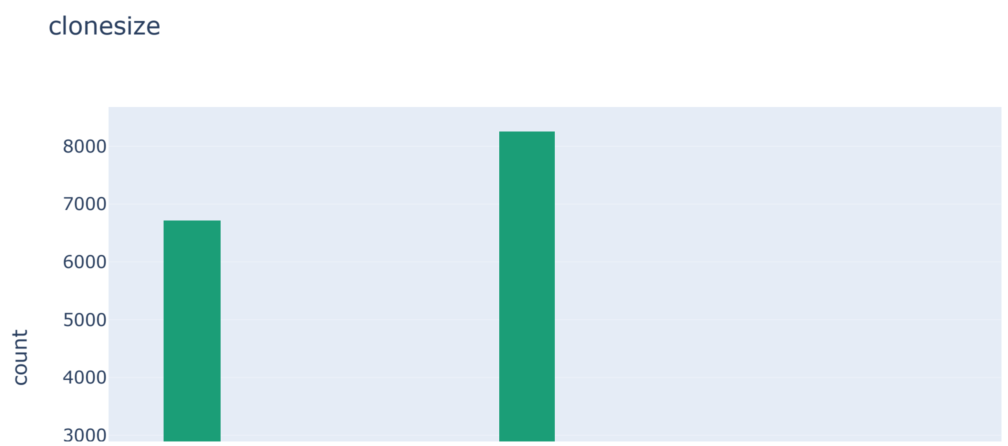
```
for i in df1.columns:
    print(i, ':')
    plt.figure(figsize=(15,6))
    sns.countplot(x = df1[i], data = df1, palette = 'hls')
    plt.xticks(rotation = 90)
    plt.show()
```



```
andrena :
```

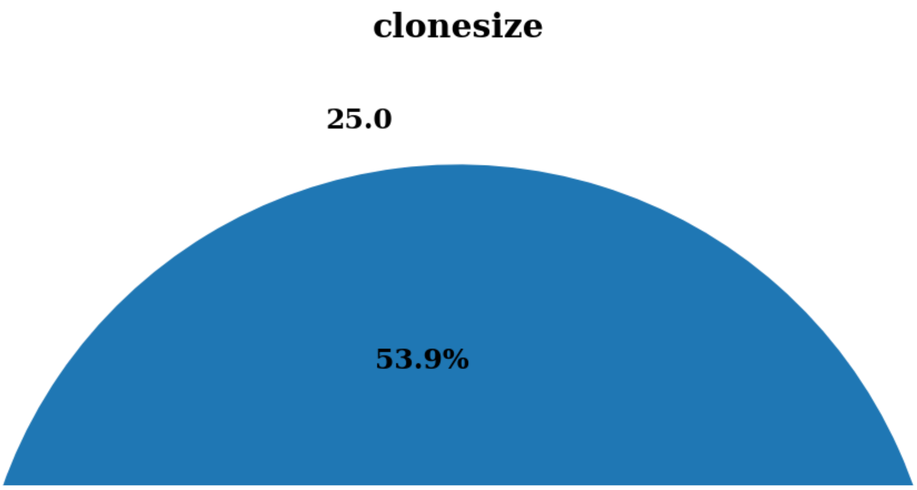
In [34]:

```
import plotly.express as px

for i in df1.columns:
    fig = px.histogram(df1, x=i, title=i, color_discrete_sequence=px.colors.qualitative.Dark2)
    fig.update_xaxes(tickangle=90)
    fig.show()
```



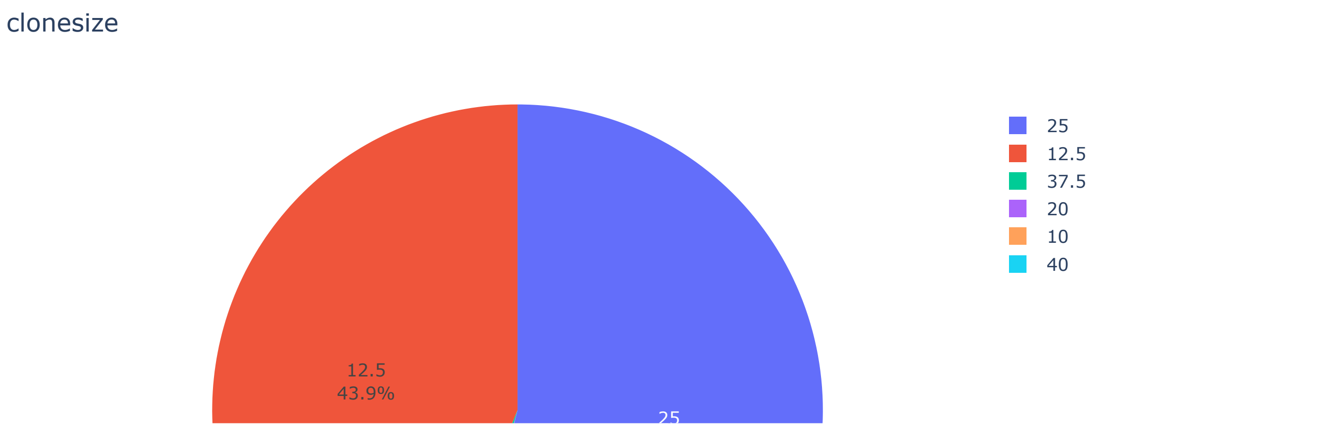
In [31]:

```
for i in df1.columns:
    plt.figure(figsize=(30,20))
    plt.pie(df1[i].value_counts(), labels=df1[i].value_counts().index, autopct='%1.1f%%', textprops={ 'fontsize': 25,
                                                                                                   'color': 'black',
                                                                                                   'weight': 'bold',
                                                                                                   'family': 'serif' })

    hfont = {'fontname':'serif', 'weight': 'bold'}
    plt.title(i, size=30, **hfont)
    plt.show()
```



In [32]:

```
for i in df1.columns:
    fig = px.pie(df1[i].value_counts(), values=df1[i].value_counts(), names=df1[i].value_counts().index,
                title=i, width=800, height=600)
    fig.update_traces(textposition='inside', textinfo='percent+label')
    fig.show()
```



In [35]:

```
df_corr = df.corr()
```

In [36]:

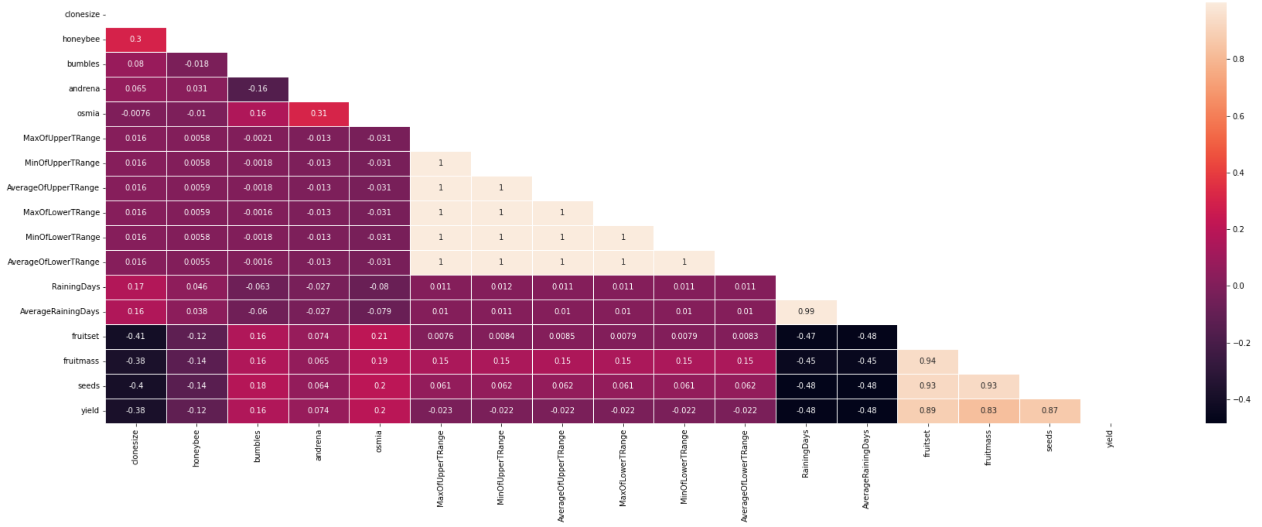
```
df_corr
```

Out[36]:

	clonesize	honeybee	bumbles	andrena	osmia	MaxOfUpperTRange	MinOfUpperTRange	AverageOfUpperTRan
clonesize	1.000000	0.304130	0.080433	0.065131	-0.007607	0.016159	0.015838	0.0160
honeybee	0.304130	1.000000	-0.017937	0.030671	-0.010394	0.005840	0.005755	0.0058
bumbles	0.080433	-0.017937	1.000000	-0.164962	0.158001	-0.002104	-0.001813	-0.0017
andrena	0.065131	0.030671	-0.164962	1.000000	0.309556	-0.013061	-0.012928	-0.0129
osmia	-0.007607	-0.010394	0.158001	0.309556	1.000000	-0.031391	-0.030819	-0.0314
MaxOfUpperTRange	0.016159	0.005840	-0.002104	-0.013061	-0.031391	1.000000	0.998599	0.9998
MinOfUpperTRange	0.015838	0.005755	-0.001813	-0.012928	-0.030819	0.998599	1.000000	0.9990
AverageOfUpperTRange	0.016057	0.005892	-0.001769	-0.012993	-0.031415	0.999806	0.999004	1.0000
MaxOfLowerTRange	0.016343	0.005942	-0.001613	-0.012924	-0.031398	0.999503	0.998199	0.9994
MinOfLowerTRange	0.016026	0.005809	-0.001804	-0.013035	-0.031486	0.999829	0.998953	0.9999
AverageOfLowerTRange	0.015987	0.005485	-0.001644	-0.013071	-0.031337	0.999772	0.999040	0.9999
RainingDays	0.165770	0.046494	-0.063294	-0.026572	-0.079874	0.011322	0.011727	0.0112
AverageRainingDays	0.164823	0.037532	-0.060232	-0.027193	-0.078720	0.010352	0.010767	0.0102
fruitset	-0.406793	-0.120492	0.160447	0.073669	0.209495	0.007580	0.008409	0.0085
fruitmass	-0.377688	-0.135310	0.163987	0.064722	0.192210	0.146237	0.147203	0.1476
seeds	-0.396898	-0.139261	0.177022	0.063504	0.200597	0.060963	0.061812	0.0620
yield	-0.382619	-0.118001	0.161145	0.073969	0.198264	-0.022517	-0.021929	-0.0219

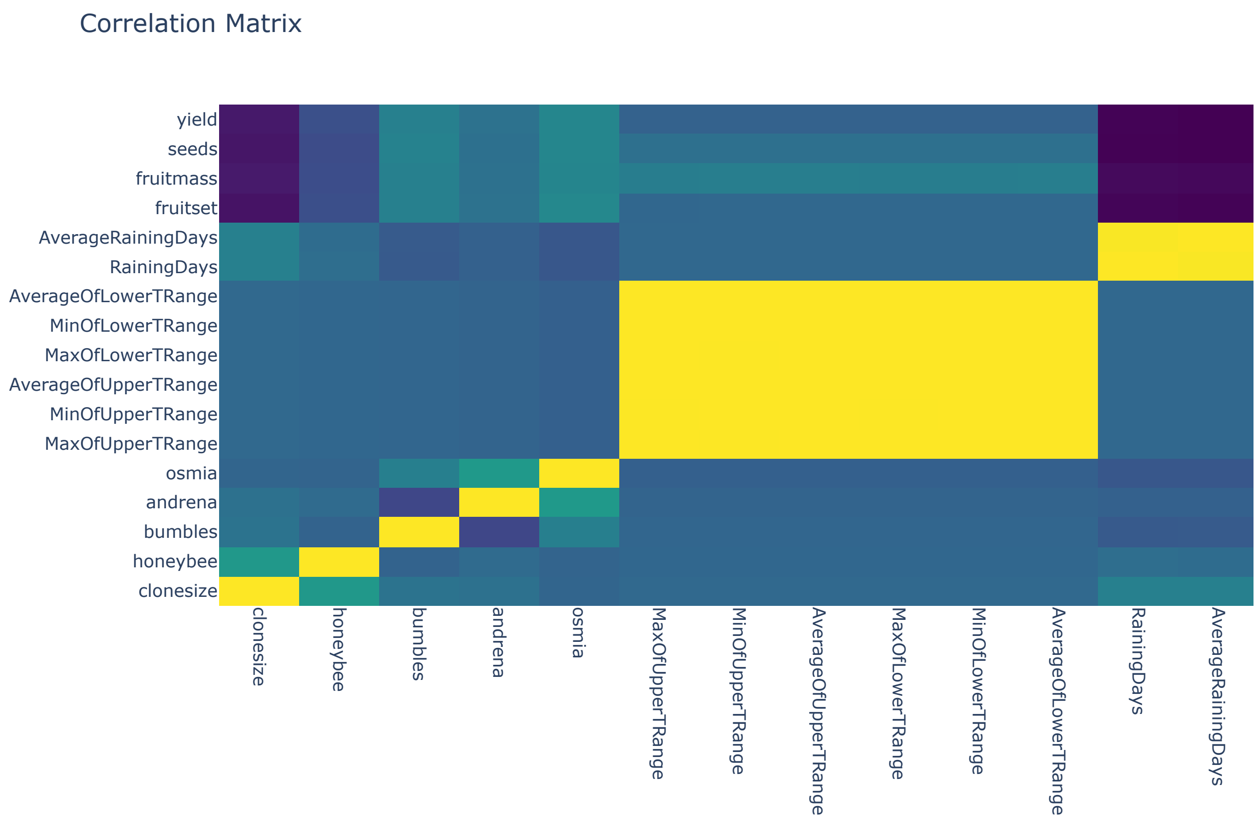
In [38]:

```
plt.figure(figsize=(30, 10))
matrix = np.triu(df_corr)
sns.heatmap(df_corr, annot=True, linewidth=.8, mask=matrix, cmap="rocket");
plt.show()
```



In [41]:

```
import plotly.graph_objects as go

fig = go.Figure(data=go.Heatmap(
                   z=df_corr,
                   x=df_corr.columns,
                   y=df_corr.index,
                   colorscale='Viridis',
                   hoverongaps=False))

fig.update_layout(
    title='Correlation Matrix',
    xaxis=dict(tickangle=90),
    height=600,
    width=1200
)

fig.show()
```



In [47]:

```
X = df.drop('yield',axis=1)
Y = df['yield']
```

In [48]:

```
from sklearn.model_selection import train_test_split
```

In [49]:

```
from sklearn.linear_model import LinearRegression
```

In [50]:

```
X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.2, random_state=42)
```

In [51]:

```
regressor = LinearRegression()
regressor.fit(X_train, y_train)
```

Out[51]:

```
▾ LinearRegression
LinearRegression()
```

In [52]:

```
y_pred = regressor.predict(X_test)
mse = ((y_pred - y_test) ** 2).mean()
print("Mean squared error:", mse)
```

```
Mean squared error: 333169.7877732821
```

In [53]:

```
from sklearn.metrics import r2_score
```

In [54]:

```
r2 = r2_score(y_test, y_pred)
print('R-squared score:', r2)
```

```
R-squared score: 0.810476696897496
```

In [55]:

```
from sklearn.tree import DecisionTreeRegressor
```

In [56]:

```
tree_reg = DecisionTreeRegressor(random_state=42)
```

In [57]:

```
tree_reg.fit(X_train, y_train)
```

Out[57]:

```
▾         DecisionTreeRegressor
DecisionTreeRegressor(random_state=42)
```

In [58]:

```
y_pred = tree_reg.predict(X_test)
```

In [59]:

```
r2_score = r2_score(y_test, y_pred)
```

In [60]:

```
print("R-squared score of DecisionTreeRegressor:", r2_score)
```

```
R-squared score of DecisionTreeRegressor: 0.6389661625506569
```

In [61]:

```
from xgboost import XGBRegressor
```

In [62]:

```
model = XGBRegressor()
```

In [63]:

```
model.fit(X_train, y_train)
```

Out[63]:

```
▾                          XGBRegressor
XGBRegressor(base_score=0.5, booster='gbtree', callbacks=None,
             colsample_bylevel=1, colsample_bynode=1, colsample_bytree=1,
             early_stopping_rounds=None, enable_categorical=False,
             eval_metric=None, gamma=0, gpu_id=-1, grow_policy='depthwise',
             importance_type=None, interaction_constraints='',
             learning_rate=0.300000012, max_bin=256, max_cat_to_onehot=4,
             max_delta_step=0, max_depth=6, max_leaves=0, min_child_weight=1,
             missing=nan, monotone_constraints='()', n_estimators=100, n_jobs=0,
             num_parallel_tree=1, predictor='auto', random_state=0, reg_alpha=0,
             reg_lambda=1, ...)
```

In [64]:

```
y_pred = model.predict(X_test)
```

In [66]:

```
from sklearn.metrics import r2_score
```

In [67]:

```
r2 = r2_score(y_test, y_pred)
print("R2 score:", r2)
```

```
R2 score: 0.8144045120706109
```