Omdena - Milan Chapter Agrifoods

AI for Sustainable agri-food systems: use of Satellite Imagery

Exploratory analysis of cereals production in Italy 2020-2022

Author: Maria Fisher

Here we have analysed the major areas and crop production in Italy. Crop dataset used in this study was downloaded from the Italian National Institute of Statistics (Istat). The objective is to get some insights about crop production and its respective areas in Italy and how climate change have affected crop production in the last 3 years.

	ITTER107	Territory	TIPO_DATO5	Data type	AGRI_MADRE	Type of crop	TIME	Select time	Value	Flag Codes	Flags
0	ITC11	Torino	ART	total area - hectares	COMMEAT	common wheat	2020	2020	15362	NaN	NaN
1	ITC11	Torino	ART	total area - hectares	COMMEAT	common wheat	2021	2021	16831	NaN	NaN
2	ITC11	Torino	ART	total area - hectares	COMMEAT	common wheat	2022	2022	16735	NaN	NaN
3	ITC11	Torino	TP_QUIN_EXT	total production - quintals	COMMEAT	common wheat	2020	2020	844910	NaN	NaN
4	ITC11	Torino	TP_QUIN_EXT	total production - quintals	COMMEAT	common wheat	2021	2021	925705	NaN	NaN

Pre-processing dataset

	Territory	Data type	Type of crop	Select time	Value
0	Torino	total area - hectares	common wheat	2020	15362
1	Torino	total area - hectares	common wheat	2021	16831
2	Torino	total area - hectares	common wheat	2022	16735
3	Torino	total production - quintals	common wheat	2020	844910
4	Torino	total production - quintals	common wheat	2021	925705
...	...	...	...	...	...
12125	Pesaro e Urbino	total area - hectares	rye and winter cereal mixtures (maslin)	2022	3
12126	Roma	total area - hectares	rye and winter cereal mixtures (maslin)	2022	20
12127	Valle d'Aosta / Vallée d'Aoste	total area - hectares	winter barley	2022	1
12128	Torino	total area - hectares	spring barley	2022	220
12129	Valle d'Aosta / Vallée d'Aoste	total area - hectares	oats and spring cereal mixtures (mixed grain o...	2022	3

12130 rows × 5 columns

```
DATASET SHAPE:  (12130, 5)

----------------------------------------------------
FEATURE DATA TYPES:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 12130 entries, 0 to 12129
Data columns (total 5 columns):
 #   Column     Non-Null Count  Dtype 
---  ------     --------------  ----- 
 0   City       12130 non-null  object
 1   Data_type  12130 non-null  object
 2   Type_crop  12130 non-null  object
 3   Year       12130 non-null  int64 
 4   Value      12130 non-null  int64 
dtypes: int64(2), object(3)
memory usage: 474.0+ KB
None

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NUMBER OF UNIQUE VALUES PER FEATURE:

City          107
Data_type       3
Type_crop      24
Year            3
Value        3103
dtype: int64

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NULL VALUES PER FEATURE
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Data_type    0
Type_crop    0
Year         0
Value        0
dtype: int64
```

Cities in Italy producing cereals

```
array(['Torino', 'Vercelli', 'Biella', 'Verbano-Cusio-Ossola', 'Novara',
       'Cuneo', 'Asti', 'Alessandria', "Valle d'Aosta / Vallée d'Aoste",
       'Savona', 'Genova', 'La Spezia', 'Varese', 'Como', 'Lecco',
       'Sondrio', 'Milano', 'Bergamo', 'Brescia', 'Pavia', 'Lodi',
       'Cremona', 'Mantova', 'Trentino Alto Adige / Südtirol', 'Verona',
       'Vicenza', 'Belluno', 'Treviso', 'Venezia', 'Padova', 'Rovigo',
       'Pordenone', 'Udine', 'Gorizia', 'Piacenza', 'Parma',
       "Reggio nell'Emilia", 'Modena', 'Bologna', 'Ferrara', 'Ravenna',
       'Forlì-Cesena', 'Rimini', 'Massa-Carrara', 'Lucca', 'Pistoia',
       'Firenze', 'Prato', 'Livorno', 'Pisa', 'Arezzo', 'Siena',
       'Grosseto', 'Perugia', 'Terni', 'Pesaro e Urbino', 'Ancona',
       'Macerata', 'Ascoli Piceno', 'Viterbo', 'Rieti', 'Roma', 'Latina',
       'Frosinone', 'Abruzzo', "L'Aquila", 'Teramo', 'Pescara', 'Chieti',
       'Isernia', 'Campobasso', 'Caserta', 'Benevento', 'Avellino',
       'Salerno', 'Foggia', 'Bari', 'Taranto', 'Brindisi', 'Potenza',
       'Matera', 'Cosenza', 'Crotone', 'Catanzaro', 'Vibo Valentia',
       'Reggio di Calabria', 'Messina', 'Catania', 'Sassari', 'Nuoro',
       'Cagliari', 'Oristano', 'Lecce', 'Trapani', 'Palermo', 'Agrigento',
       'Caltanissetta', 'Siracusa', 'Ragusa', 'Napoli',
       'Monza e della Brianza', 'Fermo', 'Barletta-Andria-Trani', 'Enna',
       'Sud Sardegna', 'Bolzano / Bozen', 'Imperia'], dtype=object)

array(['total area - hectares', 'total production - quintals ',
       'harvested production - quintals '], dtype=object)
```

Select only Values for total production - quintals

In general crop production is reported in tonnes per hectare , however Istat (http://dati.istat.it) does not give variables definition, so we have assumed that the column 'Value' for rows containing data for 'harvested production - quintals', are values for total production of cereals.

	City	Data_type	Type_crop	Year	Value
3	Torino	total production - quintals	common wheat	2020	844910
4	Torino	total production - quintals	common wheat	2021	925705
5	Torino	total production - quintals	common wheat	2022	836750
12	Vercelli	total production - quintals	common wheat	2020	64250
13	Vercelli	total production - quintals	common wheat	2021	74550

	City	Data_type	Type_crop	Year	Total_production
3	Torino	total production - quintals	common wheat	2020	844910
4	Torino	total production - quintals	common wheat	2021	925705
5	Torino	total production - quintals	common wheat	2022	836750
12	Vercelli	total production - quintals	common wheat	2020	64250
13	Vercelli	total production - quintals	common wheat	2021	74550
...	...	...	...	...	...
12059	Trentino Alto Adige / Südtirol	total production - quintals	winter barley	2022	200
12064	Trentino Alto Adige / Südtirol	total production - quintals	spring barley	2021	1890
12065	Trentino Alto Adige / Südtirol	total production - quintals	spring barley	2022	1700
12070	Trentino Alto Adige / Südtirol	total production - quintals	oats and spring cereal mixtures (mixed grain o...	2021	372
12071	Trentino Alto Adige / Südtirol	total production - quintals	oats and spring cereal mixtures (mixed grain o...	2022	280

4042 rows × 5 columns

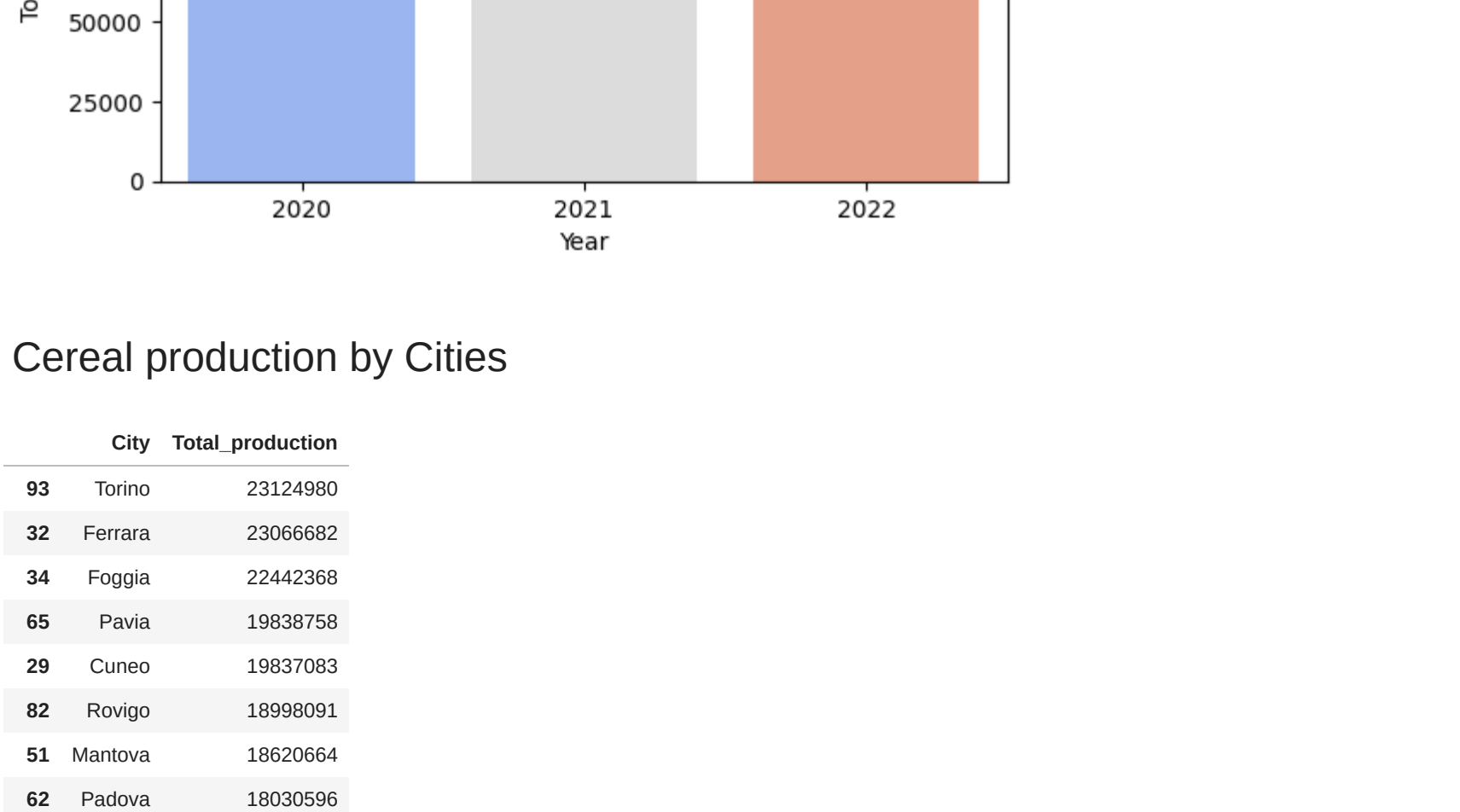
	City	Type_crop	Year	Total_production
3	Torino	common wheat	2020	844910
4	Torino	common wheat	2021	925705
5	Torino	common wheat	2022	836750
12	Vercelli	common wheat	2020	64250
13	Vercelli	common wheat	2021	74550
...	...	...	...	...
12059	Trentino Alto Adige / Südtirol	winter barley	2022	200
12064	Trentino Alto Adige / Südtirol	spring barley	2021	1890
12065	Trentino Alto Adige / Südtirol	spring barley	2022	1700
12070	Trentino Alto Adige / Südtirol	oats and spring cereal mixtures (mixed grain o...	2021	372
12071	Trentino Alto Adige / Südtirol	oats and spring cereal mixtures (mixed grain o...	2022	280

4042 rows × 4 columns

Total cereal production in 2020-2022

Cereal production by Cities

	City	Total_production
93	Torino	23124980
32	Ferrara	23066682
34	Foggia	22442368
65	Pavia	19838758
29	Cuneo	19837083
82	Rovigo	18998091
51	Mantova	18620664
62	Padova	18030596
100	Venezia	17475472
14	Bologna	16209589



Italy geographic areas is organized in regions, provinces or comunes.

The regions are classified as follow:

Sud/Mezzogiorno:

Abruzzo, Apulia/Puglia, Basilicata, Calabria, Campania, Molise, Sicily

- Abruzzo: L'Aquila, Pescara, Chieti, Teramo
- Apulia/Puglia: Foggia, Bari, Taranto, Brindisi, Lecce, Barletta-Andria-Trani
- Basilicata: Matera, Potenza
- Calabria: Crotone, Vibo, Valentia, Cosenza, Catanzaro, Reggio di Calabria
- Campania: Benevento, Caserta, Napoli, Avellino, Salerno
- Molise: Campobasso, Isernia
- Sicilia: Messina,Siracusa, Agrigento, Caltanissetta, Trapani, Enna, Palermo, Catania, Ragusa
- Sardegna: Oristano, Carbonia-Iglesias, Olbia-Tempio, Ogliastr, Medio Campidano, Sassari, Nuoro, Cagliari

Centro:

Toscana, Umbria, Marche, Lazio

- Toscana: Pistoia, Firenze, Massa-Carrara, Lucca, Arezzo, Livorno, Pisa, Grosseto, Siena, Prato
- Umbria: Perugia, Terni
- Marche: Ancona, Macerata, Ascoli Piceno, Pesaro e Urbino, Fermo
- Lazio: Roma, Viterbo, Rieti, Latina, Frosinone

Nord-ovest:

Piemonte, Valle d'Aosta, Lombardia, Liguria

- Liguria: Imperia, Savona, Genova, La Spezia
- Lombardia: Como, Varese, Milano, Pavia, Bergamo, Brescia, Sondrio, Cremona, Mantova, Monza e Della Brianza, Lecco,Lodi
- Piemonte: Vercelli, Novara, Torino, Cuneo, Asti, Alessandria, Biella, Verbano-Cusio-Ossola
- Valdaosta: Valle d'Aosta

Nord-est:

Trentino-Alto Adige, Veneto, Fiuli-Venezia Giulia, Emilia-Romagna

- Trentino: Bolzano/Bozen, Trento
- Veneto: Belluno, Verona, Vicenza, Rovigo, Treviso, Venezia, Padova
- Friuli: Udine, Gorizia, Trieste, Pordenone
- Emilia-Romagna: Parma, Reggio Nell'Emilia, Piacenza, Forli'-Cesena, Modena, Bologna, Ferrara, Ravenna, Rimini

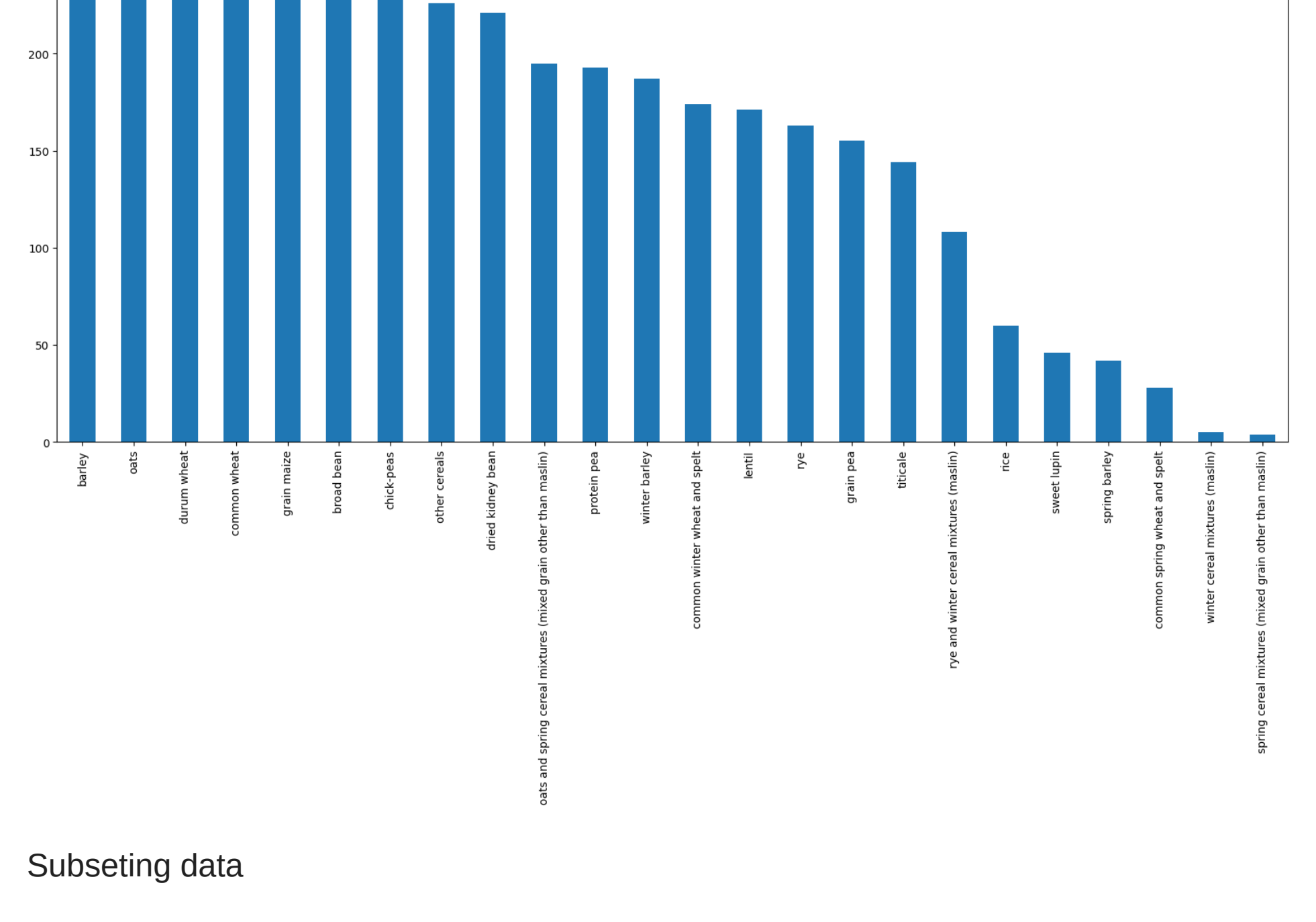
Cereals highest production 2020-2022

```
winter cereal mixtures (maslin)
barley                                                            300
oats                                                              290
durum wheat                                                       286
common wheat                                                      284
grain maize                                                       284
broad bean                                                        241
chick-peas                                                        235
other cereals                                                     226
dried kidney bean                                                 221
oats and spring cereal mixtures (mixed grain other than maslin)   195
protein pea                                                       193
winter barley                                                     187
common winter wheat and spelt                                     174
lentil                                                            171
rye                                                               163
grain pea                                                         155
titicale                                                          144
rye and winter cereal mixtures (maslin)                           108
rice                                                               60
sweet lupin                                                        46
spring barley                                                      42
common spring wheat and spelt                                      28
winter cereal mixtures (maslin)                                     5
spring cereal mixtures (mixed grain other than maslin)              4
Name: Type_crop, dtype: int64
24
```

Dataset shows there are 24 different types of cereals cultivated in Italy. The top five most produced crops are Wheat, Barley, Maize, Beans and Oats.

	Year	Total_production
count	4042.000000	4.042000e+03
mean	2021.082880	1.411529e+05
std	0.788942	4.820117e+05
min	2020.000000	0.000000e+00
25%	2020.000000	7.200000e+02
50%	2021.000000	5.032500e+03
75%	2022.000000	6.392000e+04
max	2022.000000	7.500000e+06

<AxesSubplot: >



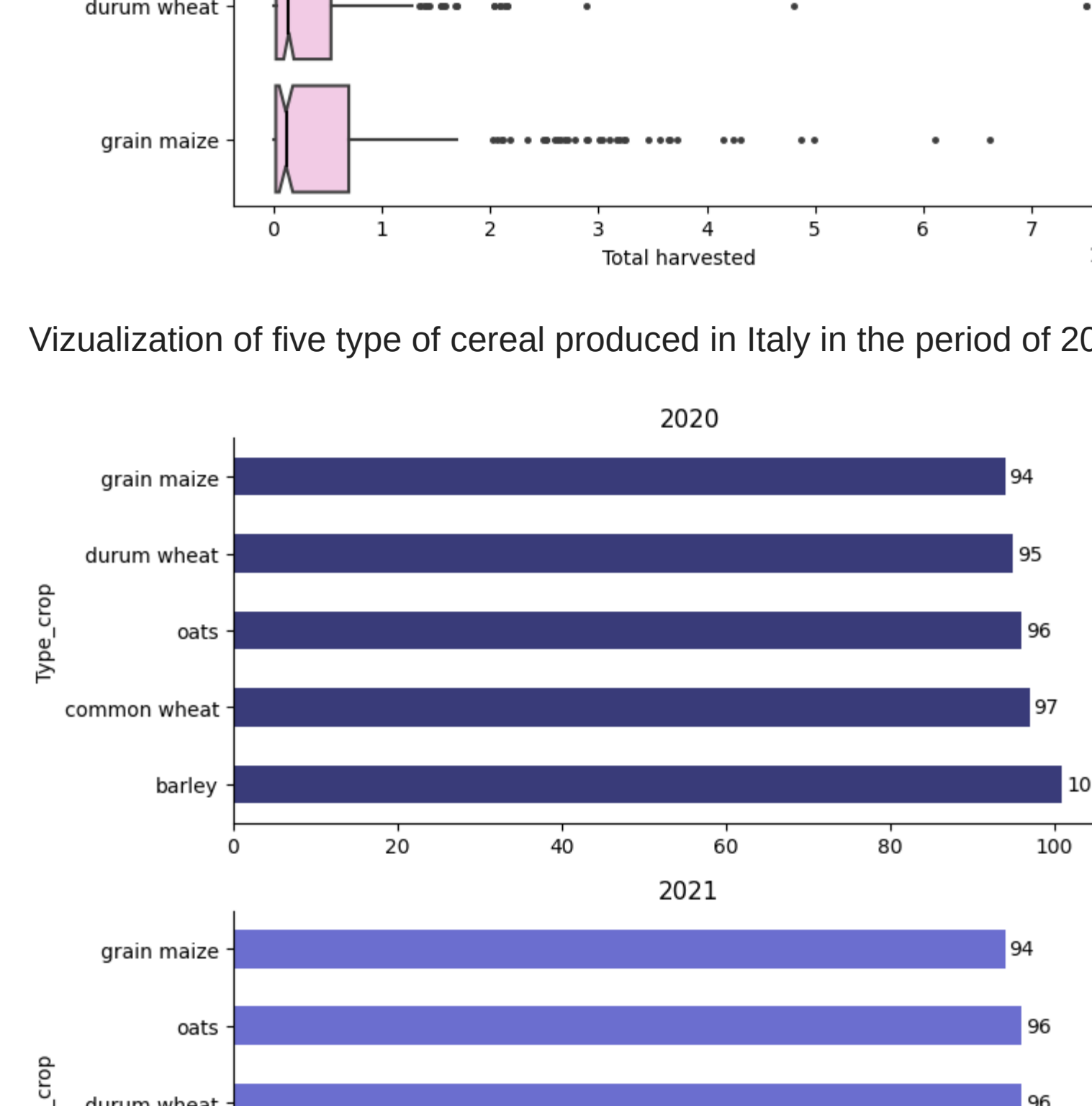
Subseting data

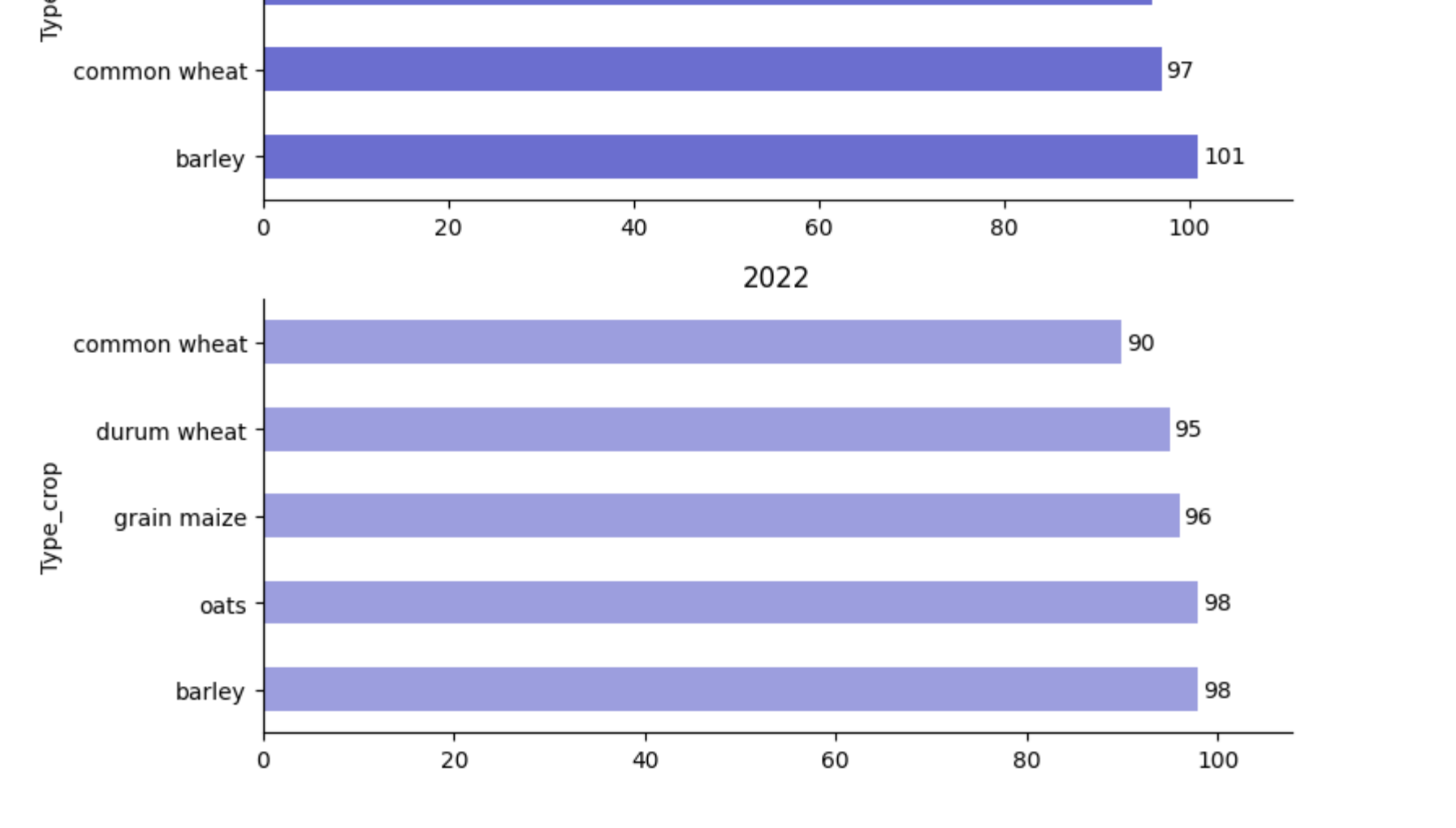
	City	Type_crop	Year	Total_production
3	Torino	common wheat	2020	844910
4	Torino	common wheat	2021	925705
5	Torino	common wheat	2022	836750
12	Vercelli	common wheat	2020	64250
13	Vercelli	common wheat	2021	74550

Stats

	Year	Total_production
count	1444	1444
mean	2020	304659
std	0	696586
min	2020	0
25%	2020	5606
50%	2021	62000
75%	2022	232845
max	2022	7500000

Vizualization of five type of cereal production in Italy in the period of 2020-2022





	City	Type_crop	Year	Total_production
3	Torino	common wheat	2020	844910
12	Vercelli	common wheat	2020	64250
21	Biella	common wheat	2020	5590
30	Verbano-Cusio-Ossola	common wheat	2020	130
39	Novara	common wheat	2020	60550
...	...	...	...	...
8605	Sud Sardegna	durum wheat	2020	396335
8614	Bolzano / Bozen	common wheat	2020	1400
8632	Bolzano / Bozen	barley	2020	2205
8641	Bolzano / Bozen	oats	2020	352
8650	Bolzano / Bozen	grain maize	2020	256

483 rows × 4 columns

		Total_production				
	Type_crop	barley	common wheat	durum wheat	grain maize	oats
City	Year					
Abruzzo	2020	701200.0	915055.0	1272250.0	640900.0	68600.0
Agrigento	2020	21600.0	NaN	575100.0	NaN	18500.0
Alessandria	2020	277530.0	997605.0	75560.0	2336125.0	13475.0
Ancona	2020	115611.0	9008.0	2036568.0	196603.0	1555.0
Arezzo	2020	117000.0	247000.0	129000.0	147000.0	14300.0
...	...	...	...	...	...	...
Vercelli	2020	44110.0	64250.0	583.0	1114320.0	2650.0
Verona	2020	214925.0	914350.0	87980.0	3010230.0	900.0
Vibo Valentia	2020	13500.0	34800.0	33000.0	27900.0	44200.0
Vicenza	2020	158750.0	459370.0	32240.0	1688515.0	1240.0
Viterbo	2020	555000.0	136000.0	749000.0	178000.0	31100.0

106 rows × 5 columns

	Type_crop	barley	common wheat	durum wheat	grain maize	oats
City	Year					
Abruzzo	2020	701200.0	915055.0	1272250.0	640900.0	68600.0
Agrigento	2020	21600.0	NaN	575100.0	NaN	18500.0
Alessandria	2020	277530.0	997605.0	75560.0	2336125.0	13475.0
Ancona	2020	115611.0	9008.0	2036568.0	196603.0	1555.0
Arezzo	2020	117000.0	247000.0	129000.0	147000.0	14300.0
...	...	...	...	...	...	...
Vercelli	2020	44110.0	64250.0	583.0	1114320.0	2650.0
Verona	2020	214925.0	914350.0	87980.0	3010230.0	900.0
Vibo Valentia	2020	13500.0	34800.0	33000.0	27900.0	44200.0
Vicenza	2020	158750.0	459370.0	32240.0	1688515.0	1240.0
Viterbo	2020	555000.0	136000.0	749000.0	178000.0	31100.0

106 rows × 5 columns

	Type_crop	barley	common wheat	durum wheat	grain maize	oats
City	Year					
Abruzzo	2020	701200.0	915055.0	1272250.0	640900.0	68600.0
Agrigento	2020	21600.0	0.0	575100.0	0.0	18500.0
Alessandria	2020	277530.0	997605.0	75560.0	2336125.0	13475.0
Ancona	2020	115611.0	9008.0	2036568.0	196603.0	1555.0
Arezzo	2020	117000.0	247000.0	129000.0	147000.0	14300.0
...	...	...	...	...	...	...
Vercelli	2020	44110.0	64250.0	583.0	1114320.0	2650.0
Verona	2020	214925.0	914350.0	87980.0	3010230.0	900.0
Vibo Valentia	2020	13500.0	34800.0	33000.0	27900.0	44200.0
Vicenza	2020	158750.0	459370.0	32240.0	1688515.0	1240.0
Viterbo	2020	555000.0	136000.0	749000.0	178000.0	31100.0

106 rows × 5 columns

		barley	common wheat	durum wheat	grain maize	oats
City	Year					
Abruzzo	2020	701200.0	915055.0	1272250.0	640900.0	68600.0
Agrigento	2020	21600.0	0.0	575100.0	0.0	18500.0
Alessandria	2020	277530.0	997605.0	75560.0	2336125.0	13475.0
Ancona	2020	115611.0	9008.0	2036568.0	196603.0	1555.0
Arezzo	2020	117000.0	247000.0	129000.0	147000.0	14300.0
...	...	...	...	...	...	...
Vercelli	2020	44110.0	64250.0	583.0	1114320.0	2650.0
Verona	2020	214925.0	914350.0	87980.0	3010230.0	900.0
Vibo Valentia	2020	13500.0	34800.0	33000.0	27900.0	44200.0
Vicenza	2020	158750.0	459370.0	32240.0	1688515.0	1240.0
Viterbo	2020	555000.0	136000.0	749000.0	178000.0	31100.0

106 rows × 5 columns

	City	Year	barley	common wheat	durum wheat	grain maize	oats
0	Abruzzo	2020	701200.0	915055.0	1272250.0	640900.0	68600.0
1	Agrigento	2020	21600.0	0.0	575100.0	0.0	18500.0
2	Alessandria	2020	277530.0	997605.0	75560.0	2336125.0	13475.0
3	Ancona	2020	115611.0	9008.0	2036568.0	196603.0	1555.0
4	Arezzo	2020	117000.0	247000.0	129000.0	147000.0	14300.0
...	...	...	...	...	...	...	...
101	Vercelli	2020	44110.0	64250.0	583.0	1114320.0	2650.0
102	Verona	2020	214925.0	914350.0	87980.0	3010230.0	900.0
103	Vibo Valentia	2020	13500.0	34800.0	33000.0	27900.0	44200.0
104	Vicenza	2020	158750.0	459370.0	32240.0	1688515.0	1240.0
105	Viterbo	2020	555000.0	136000.0	749000.0	178000.0	31100.0

106 rows × 7 columns

Pre-processing ferlizers dataset

	ITTER107	Territory	TIPO_DATO5	Data type	FERTILIZZANTI	Type of fertilizer	TIME	Select time	Value	Flag Codes	Flags
0	ITD59	Rimini	FERT_DISTRIB_T	fertilizers distributed - tonnes	CON_MIN_MICRO	containing micronutrients	2019	2019	11	NaN	NaN
1	ITD59	Rimini	FERT_DISTRIB_T	fertilizers distributed - tonnes	CON_MIN_MICRO	containing micronutrients	2020	2020	11	NaN	NaN
2	ITD59	Rimini	FERT_DISTRIB_T	fertilizers distributed - tonnes	CON_MIN_MICRO	containing micronutrients	2021	2021	3	NaN	NaN
3	ITD44	Trieste	FERT_DISTRIB_T	fertilizers distributed - tonnes	AMM_TORB_COMP	peaty soil amendment	2019	2019	8	NaN	NaN
4	ITD44	Trieste	FERT_DISTRIB_T	fertilizers distributed - tonnes	AMM_TORB_COMP	peaty soil amendment	2020	2020	105	NaN	NaN

	Territory	Data type	Type of fertilizer	Select time	Value
0	Rimini	fertilizers distributed - tonnes	containing micronutrients	2019	11
1	Rimini	fertilizers distributed - tonnes	containing micronutrients	2020	11
2	Rimini	fertilizers distributed - tonnes	containing micronutrients	2021	3
3	Trieste	fertilizers distributed - tonnes	peaty soil amendment	2019	8
4	Trieste	fertilizers distributed - tonnes	peaty soil amendment	2020	105
...	...	...	...	...	...
17670	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2020	422
17671	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2021	543
17672	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2019	164
17673	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2020	135
17674	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2021	193

17675 rows × 5 columns

```
array(['Rimini', 'Trieste', 'Pisa', 'Pordenone', 'Venezia', 'Firenze',
       'Perugia', 'Enna', 'Nuoro', 'Ferrara', 'Bologna', 'Ascoli Piceno',
       'Roma', 'Verona', 'Messina', 'Parma', 'Oristano', 'Siena',
       'Vibo Valentia', 'Monza e della Brianza', 'Varese', 'Novara',
       'Lecco', 'Grosseto', 'Rieti', 'Pavia', 'Ancona', 'Pesaro e Urbino',
       'Forlì-Cesena', 'Reggio di Calabria', 'Chieti', 'Cremona', 'Udine',
       'Lecce', 'Avellino', 'Potenza', 'Lucca', 'Padova', 'Gorizia',
       'Savona', 'Pescara', 'Caltanissetta', 'Brescia',
       'Trentino Alto Adige / Südtirol', 'Benevento', 'Viterbo',
       'Sassari', 'Treviso', 'Como', 'Provincia Autonoma Bolzano / Bozen',
       'Teramo', 'Latina', 'Catania', "Valle d'Aosta / Vallée d'Aoste",
       'Verbano-Cusio-Ossola', 'Belluno', 'Catanzaro', 'Genova',
       'Sondrio', 'Modena', 'Alessandria', 'Piacenza', 'Caserta',
       'Isernia', 'Prato', 'Arezzo', 'Agrigento', 'Matera', 'Cagliari',
       'Pistoia', 'Salerno', 'Crotone', 'Vercelli', 'Fermo',
       'Provincia Autonoma Trento', 'Napoli', 'Bergamo',
       "Reggio nell'Emilia", 'Taranto', 'Mantova', 'Ravenna', 'Asti',
       'Torino', 'Foggia', 'Campobasso', 'La Spezia', 'Livorno',
       'Cosenza', 'Ragusa', 'Palermo', 'Massa-Carrara', 'Macerata',
       'Rovigo', 'Biella', 'Cuneo', 'Trapani', 'Imperia', 'Siracusa',
       'Brindisi', 'Barletta-Andria-Trani', "L'Aquila", 'Vicenza', 'Bari',
       'Terni', 'Milano', 'Lodi', 'Frosinone', 'Sud Sardegna'],
      dtype=object)
```

	City	Data_type	Type_fertilizer	Year	Fertilizers_tonnes
0	Rimini	fertilizers distributed - tonnes	containing micronutrients	2019	11
1	Rimini	fertilizers distributed - tonnes	containing micronutrients	2020	11
2	Rimini	fertilizers distributed - tonnes	containing micronutrients	2021	3
3	Trieste	fertilizers distributed - tonnes	peaty soil amendment	2019	8
4	Trieste	fertilizers distributed - tonnes	peaty soil amendment	2020	105
...	...	...	...	...	...
17670	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2020	422
17671	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2021	543
17672	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2019	164
17673	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2020	135
17674	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2021	193

17675 rows × 5 columns

	City	Type_fertilizer	Year	Fertilizers_tonnes
0	Rimini	containing micronutrients	2019	11
1	Rimini	containing micronutrients	2020	11
2	Rimini	containing micronutrients	2021	3
3	Trieste	peaty soil amendment	2019	8
4	Trieste	peaty soil amendment	2020	105
...	...	...	...	...
17670	Sud Sardegna	specific action products -	2020	422
17671	Sud Sardegna	specific action products -	2021	543
17672	Sud Sardegna	specific action products -	2019	164
17673	Sud Sardegna	specific action products -	2020	135
17674	Sud Sardegna	specific action products -	2021	193

17675 rows × 4 columns

	City	Type_fertilizer	Year	Fertilizers_tonnes
1	Rimini	containing micronutrients	2020	11
4	Trieste	peaty soil amendment	2020	105
7	Pisa	specific action products	2020	27
10	Pordenone	three components - nitrogen-phosphorous-phosph...	2020	8547
13	Venezia	soil correctives - sulphur for agricultural use	2020	5
...	...	...	...	...
17661	Sud Sardegna	soil correctives - other soil correctives	2020	2
17664	Sud Sardegna	crop substrates	2020	112
17667	Sud Sardegna	specific action products	2020	557
17670	Sud Sardegna	specific action products -	2020	422
17673	Sud Sardegna	specific action products -	2020	135

5892 rows × 4 columns

Selecting only 6 type of fertilizers for future analysis

```
array(['containing micronutrients', 'peaty soil amendment',
       'specific action products',
       'three components - nitrogen-phosphorous-phosphorous',
       'soil correctives - sulphur for agricultural use',
       'two components - nitrogen-potassium',
       'containing micronutrients containing only a micronutrient',
       'organic fertilizers - compound', 'manure amendment',
       'vegetable soil amendment',
       'containing micronutrients containing several micronutrients in chelated form',
       'organic fertilizers - straight nitrogen',
       'other fertilizers different from sulphate and chloride ',
       'two components - phosphorus-potassium',
       'mineral fertilizers containing macronutrients and micronutrients',
       'triple superphosphate',
       'organic-mineral fertilizers - straight nitrogen',
       'other soil amendments',
       'containing only one secondary macronutrient - sulphur oxide',
       'containing micronutrients containing only a micronutrient in mineral form',
       'chloride ', 'ammonium sulphate', 'sulphate', 'amendment',
       'organic-mineral fertilizers',
       'other fertilizers different from calcium cyanamide, nitrates, ammonium sulphate, urea',
       'mixed soil amendment', 'crop substrates',
       'containing only one secondary macronutrient - calcium oxide',
       'compound mineral fertilizers',
       'soil correctives - calcium sulphate anhydrite and gypsum',
       'simple mineral fertilizers', 'specific action products - ',
       'peat amendment', 'calcium cyanamide',
       'soil correctives - calxes, limestones and dolomites',
       'nitrogen fertilizers', 'simple superphosphate',
       'containing several macronutrients',
       'containing only one secondary macronutrient - magnesium oxide',
       'organic-mineral fertilizers - compound', 'nitrates ', 'urea',
       'soil correctives - other  soil correctives',
       'organic fertilizers',
       'other fertilizers different from simple superphosphate and triple superphosphate',
       'containing micronutrients containing several micronutrients in mineral form',
       'potassium fertilizers', 'containing macronutrients',
       'two components - nitrogen-phosphorous',
       'containing micronutrients containing only a micronutrient in chelated form',
       'phosphorus fertilizers'], dtype=object)
```

```
vegetable soil amendment
specific action products -                                                            216
containing micronutrients                                                             120
mineral fertilizers containing macronutrients and micronutrients                      120
containing macronutrients                                                             120
potassium fertilizers                                                                 120
organic fertilizers                                                                   120
nitrogen fertilizers                                                                  120
simple mineral fertilizers                                                            120
compound mineral fertilizers                                                          120
crop substrates                                                                       120
organic-mineral fertilizers                                                           120
amendment                                                                             120
phosphorus fertilizers                                                                120
specific action products                                                              120
three components - nitrogen-phosphorous-phosphorous                                   120
two components - phosphorus-potassium                                                 108
nitrates                                                                              108
soil correctives - calxes, limestones and dolomites                                   108
two components - nitrogen-potassium                                                   108
simple superphosphate                                                                 108
containing several macronutrients                                                     108
containing only one secondary macronutrient - magnesium oxide                         108
organic-mineral fertilizers - compound                                                108
soil correctives - other  soil correctives                                            108
urea                                                                                  108
peat amendment                                                                        108
soil correctives - sulphur for agricultural use                                       108
other fertilizers different from simple superphosphate and triple superphosphate      108
containing micronutrients containing several micronutrients in mineral form           108
two components - nitrogen-phosphorous                                                 108
containing micronutrients containing only a micronutrient in chelated form            108
calcium cyanamide                                                                     108
containing micronutrients containing only a micronutrient                             108
other fertilizers different from sulphate and chloride                                108
sulphate                                                                              108
triple superphosphate                                                                 108
organic-mineral fertilizers - straight nitrogen                                       108
other soil amendments                                                                 108
containing only one secondary macronutrient - sulphur oxide                           108
containing micronutrients containing only a micronutrient in mineral form             108
chloride                                                                              108
ammonium sulphate                                                                     108
organic fertilizers - straight nitrogen                                               108
organic fertilizers - compound                                                        108
containing micronutrients containing several micronutrients in chelated form          108
other fertilizers different from calcium cyanamide, nitrates, ammonium sulphate, urea 108
peaty soil amendment                                                                  108
vegetable soil amendment                                                              108
containing only one secondary macronutrient - calcium oxide                           108
manure amendment                                                                      108
soil correctives - calcium sulphate anhydrite and gypsum                              108
mixed soil amendment                                                                  108
Name: Type_fertilizer, dtype: int64
52
```

	City	Type_fertilizer	Year	Fertilizers_tonnes
76	Pavia	ammonium sulphate	2020	747
154	Benevento	calcium cyanamide	2020	0
166	Treviso	ammonium sulphate	2020	1423
172	Provincia Autonoma Bolzano / Bozen	nitrogen fertilizers	2020	31
235	Alessandria	organic fertilizers	2020	2251

Create new dataframe with the selected type of fertilizers as columns

		Fertilizers_tonnes					
	Type_fertilizer	ammonium sulphate	calcium cyanamide	nitrogen fertilizers	organic fertilizers	phosphorus fertilizers	potassium fertilizers
City	Year						
Agrigento	2020	155	12	1715	4006	142	16
Alessandria	2020	135	105	20968	2251	782	743
Ancona	2020	567	17	22511	2695	1258	33
Arezzo	2020	68	26	3675	2053	72	209
Ascoli Piceno	2020	8	158	1065	1284	22	267
...	...	...	...	...	...	...	...
Vercelli	2020	14	2570	7604	6585	0	1013
Verona	2020	3919	258	66460	9529	9363	6141
Vibo Valentia	2020	1433	0	2487	92	157	0
Vicenza	2020	1350	225	10182	1252	220	351
Viterbo	2020	176	0	14138	2673	603	10

108 rows × 6 columns

	Type_fertilizer	ammonium sulphate	calcium cyanamide	nitrogen fertilizers	organic fertilizers	phosphorus fertilizers	potassium fertilizers
City	Year						
Agrigento	2020	155	12	1715	4006	142	16
Alessandria	2020	135	105	20968	2251	782	743
Ancona	2020	567	17	22511	2695	1258	33
Arezzo	2020	68	26	3675	2053	72	209
Ascoli Piceno	2020	8	158	1065	1284	22	267
...	...	...	...	...	...	...	...
Vercelli	2020	14	2570	7604	6585	0	1013
Verona	2020	3919	258	66460	9529	9363	6141
Vibo Valentia	2020	1433	0	2487	92	157	0
Vicenza	2020	1350	225	10182	1252	220	351
Viterbo	2020	176	0	14138	2673	603	10

108 rows × 6 columns

		ammonium sulphate	calcium cyanamide	nitrogen fertilizers	organic fertilizers	phosphorus fertilizers	potassium fertilizers
City	Year						
Agrigento	2020	155	12	1715	4006	142	16
Alessandria	2020	135	105	20968	2251	782	743
Ancona	2020	567	17	22511	2695	1258	33
Arezzo	2020	68	26	3675	2053	72	209
Ascoli Piceno	2020	8	158	1065	1284	22	267
...	...	...	...	...	...	...	...
Vercelli	2020	14	2570	7604	6585	0	1013
Verona	2020	3919	258	66460	9529	9363	6141
Vibo Valentia	2020	1433	0	2487	92	157	0
Vicenza	2020	1350	225	10182	1252	220	351
Viterbo	2020	176	0	14138	2673	603	10

108 rows × 6 columns

	City	Year	ammonium sulphate	calcium cyanamide	nitrogen fertilizers	organic fertilizers	phosphorus fertilizers	potassium fertilizers
0	Agrigento	2020	155	12	1715	4006	142	16
1	Alessandria	2020	135	105	20968	2251	782	743
2	Ancona	2020	567	17	22511	2695	1258	33
3	Arezzo	2020	68	26	3675	2053	72	209
4	Ascoli Piceno	2020	8	158	1065	1284	22	267
...	...	...	...	...	...	...	...	...
103	Vercelli	2020	14	2570	7604	6585	0	1013
104	Verona	2020	3919	258	66460	9529	9363	6141
105	Vibo Valentia	2020	1433	0	2487	92	157	0
106	Vicenza	2020	1350	225	10182	1252	220	351
107	Viterbo	2020	176	0	14138	2673	603	10

108 rows × 8 columns

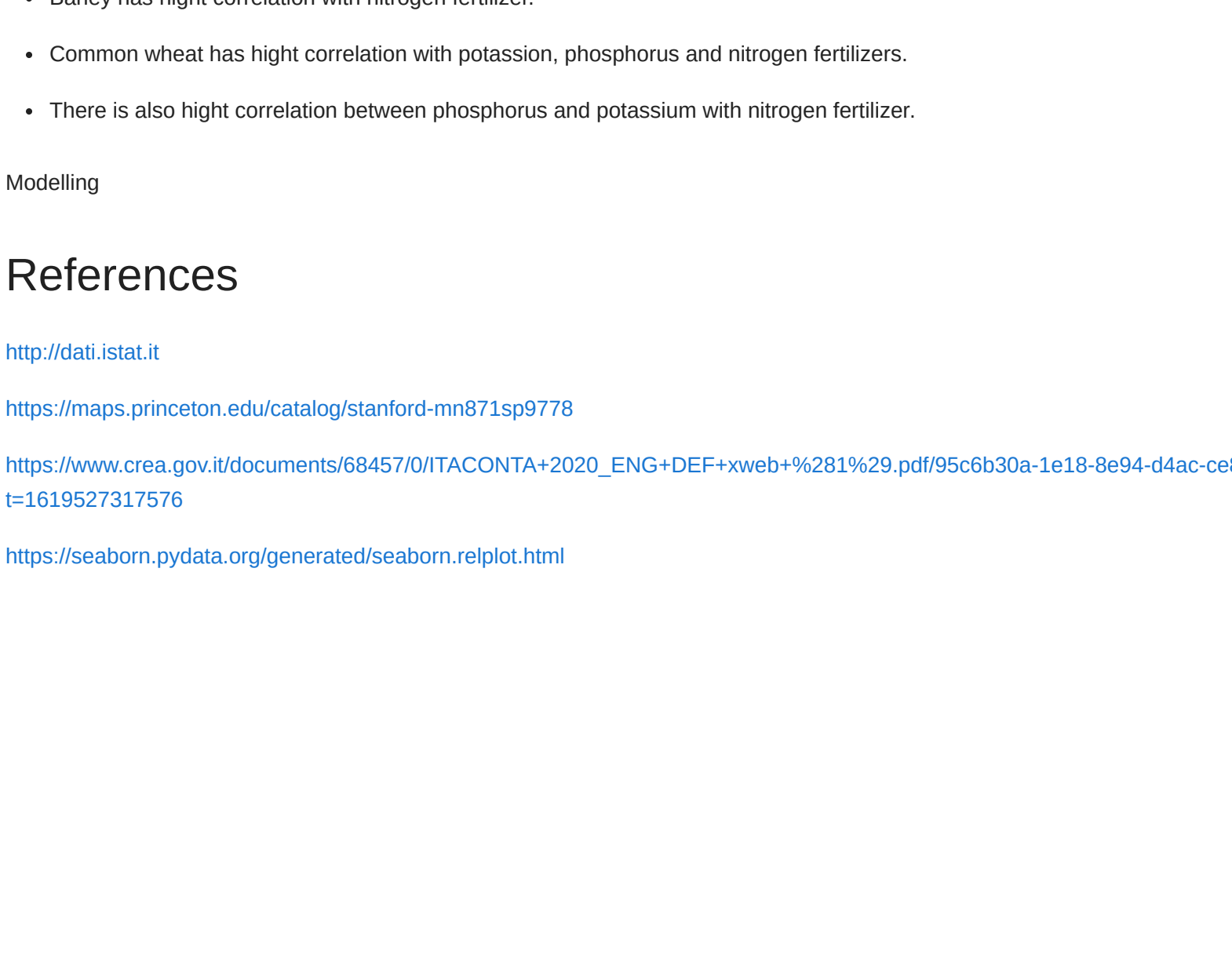
Join crop and fertilizers datasets

	City	Year	barley	common wheat	durum wheat	grain maize	oats	ammonium sulphate	calcium cyanamide	nitrogen fertilizers	organic fertilizers	phosphorus fertilizers	potassium fertilizers
0	Abruzzo	2020	701200.0	915055.0	1272250.0	640900.0	68600.0	0.0	0.0	0.0	0.0	0.0	0.0
1	Agrigento	2020	21600.0	0.0	575100.0	0.0	18500.0	155.0	12.0	1715.0	4006.0	142.0	16.0
2	Alessandria	2020	277530.0	997605.0	75560.0	2336125.0	13475.0	135.0	105.0	20968.0	2251.0	782.0	743.0
3	Ancona	2020	115611.0	9008.0	2036568.0	196603.0	1555.0	567.0	17.0	22511.0	2695.0	1258.0	33.0
4	Arezzo	2020	117000.0	247000.0	129000.0	147000.0	14300.0	68.0	26.0	3675.0	2053.0	72.0	209.0
...	...	...	...	...	...	...	...	...	...	...	...	...	...
101	Vercelli	2020	44110.0	64250.0	583.0	1114320.0	2650.0	14.0	2570.0	7604.0	6585.0	0.0	1013.0
102	Verona	2020	214925.0	914350.0	87980.0	3010230.0	900.0	3919.0	258.0	66460.0	9529.0	9363.0	6141.0
103	Vibo Valentia	2020	13500.0	34800.0	33000.0	27900.0	44200.0	1433.0	0.0	2487.0	92.0	157.0	0.0
104	Vicenza	2020	158750.0	459370.0	32240.0	1688515.0	1240.0	1350.0	225.0	10182.0	1252.0	220.0	351.0
105	Viterbo	2020	555000.0	136000.0	749000.0	178000.0	31100.0	176.0	0.0	14138.0	2673.0	603.0	10.0

106 rows × 13 columns

Correlation analysis

```
&lt;AxesSubplot: title={'center': 'Correlation'}&gt;
```



Correlation analysis of cereal production in Italy with high correlation with fertilizers:

- Maize has hight correlation with potassion and nitrogen fertilizers.
- Barley has hight correlation with nitrogen fertilizer.
- Common wheat has hight correlation with potassion, phosphorus and nitrogen fertilizers.
- There is also hight correlation between phosphorus and potassium with nitrogen fertilizer.

Modelling

References

http://dati.istat.it

https://maps.princeton.edu/catalog/stanford-mn871sp9778

https://www.crea.gov.it/documents/68457/0/ITACONTA+2020_ENG+DEF+xweb+%281%29.pdf/95c6b30a-1e18-8e94-d4ac-ce884aef76e8?t=1619527317576

https://seaborn.pydata.org/generated/seaborn.relplot.html