Agriculture production

HUL315

Submitted by:

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- Input:
    1. High-Yielding Varieties (HYVs) of agricultural crops
    2. Rainfall during cropping session
    3. Irrigation intensity
    4. Multiple-Cropping Index
- Output: **YIELD** of kharif crop
    a) Rice
    b) Bajra
    c) Maize
    d) Jowar

$$\boldsymbol{YIELD} = \beta_0 + \beta_1 HYV + \beta_2 Rainfall1 + \beta_3 Rainfall2 + \beta_4 II + \beta_5 MCI$$

S.No.	Variables	Descriptor	Mean	Std.
1	HYV	HYVRICE	17	44.9
		HYVBAJRA	6.37	16.53
		HYVJOWAR	2.88	8.91
		HYVMAIZE	1.43	2.89
2	Rainfall1	Rainfall(Jul.+Aug.,Sept.)	797.47	369.67
3	Rainfall2	Rainfall(Oct.+Nov.+Dec.)	109.5	96.42
4	II	Irrigation Intensity	0.24	0.21
5	MCI	Multiple-cropping Index	1.19	0.16

RICE:

```
Call:
lm(formula = "YRICE ~ HYVRICE+Rainfall1+Rainfall2+GCANCA+NIANCA",
    data = Excel1)

Residuals:
    Min      1Q  Median      3Q     Max
-1.0299 -0.2482 -0.0521  0.2535  1.8165

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  8.604e-01  2.228e-01   3.861 0.000142 ***
HYVRICE     -8.589e-04  7.639e-04  -1.124 0.261875
Rainfall1   -2.181e-04  7.971e-05  -2.737 0.006625 **
Rainfall2    2.789e-03  3.436e-04   8.115 1.85e-14 ***
GCANCA      -1.288e-01  2.114e-01  -0.609 0.542726
NIANCA       6.879e-01  1.582e-01   4.350 1.95e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4361 on 264 degrees of freedom
Multiple R-squared:  0.3629,    Adjusted R-squared:  0.3508
F-statistic: 30.08 on 5 and 264 DF,  p-value: < 2.2e-16
```

BAJRA:

```
Call:
lm(formula = "YBAJRA ~ HYVBAJRA+Rainfall1+Rainfall2+GCANCA+NIANCA",
    data = Excel1)

Residuals:
    Min      1Q  Median      3Q     Max
-0.7990 -0.2455 -0.0318  0.1933  3.4739

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.332e-01  2.064e-01   2.099  0.03679 *
HYVBAJRA     4.618e-03  1.571e-03   2.940  0.00358 **
Rainfall1   -1.936e-04  7.564e-05  -2.560  0.01103 *
Rainfall2   -8.946e-04  2.728e-04  -3.279  0.00118 **
GCANCA       5.128e-02  1.937e-01   0.265  0.79145
NIANCA       8.615e-01  1.440e-01   5.981 7.19e-09 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4024 on 264 degrees of freedom
Multiple R-squared:  0.2194,    Adjusted R-squared:  0.2046
F-statistic: 14.84 on 5 and 264 DF,  p-value: 7.849e-13
```

Maize:

```
Call:
lm(formula = "YMAIZE ~ HYVMAIZE+Rainfall1+Rainfall2+GCANCA+NIANCA",
    data = Excel1)

Residuals:
     Min       1Q   Median       3Q      Max
-1.21419 -0.31993 -0.04325  0.33456  2.74332

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.886e+00  3.343e-01   5.641 4.35e-08 ***
HYVMAIZE     7.845e-02  1.419e-02   5.527 7.80e-08 ***
Rainfall1   -6.874e-07  1.200e-04  -0.006  0.99543
Rainfall2   -2.824e-05  4.388e-04  -0.064  0.94873
GCANCA      -8.616e-01  3.200e-01  -2.692  0.00755 **
NIANCA       5.602e-01  2.374e-01   2.360  0.01902 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.6615 on 264 degrees of freedom
Multiple R-squared:  0.1309,    Adjusted R-squared:  0.1144
F-statistic: 7.952 on 5 and 264 DF,  p-value: 5.355e-07
```

Jowar:

```
Call:
lm(formula = "YJOWAR ~ HYVJOWAR+Rainfall1+Rainfall2+GCANCA+NIANCA",
    data = Excel1)

Residuals:
     Min       1Q   Median       3Q      Max
-0.60661 -0.28976 -0.05997  0.21485  2.70220

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  6.630e-01  2.349e-01   2.823  0.00513 **
HYVJOWAR    -1.057e-03  3.257e-03  -0.325  0.74580
Rainfall1   -1.444e-04  8.267e-05  -1.747  0.08184 .
Rainfall2    5.383e-04  3.016e-04   1.785  0.07547 .
GCANCA      -6.278e-02  2.205e-01  -0.285  0.77604
NIANCA       3.272e-02  1.643e-01   0.199  0.84231
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4548 on 264 degrees of freedom
Multiple R-squared:  0.0341,    Adjusted R-squared:  0.0158
F-statistic: 1.864 on 5 and 264 DF,  p-value: 0.101
```

Revise the model by adding extra descriptor

- Price
- Dummy variable for Aquifer depth(Ground water)
  DMAQ1: dummy variable = 1 if aquifer is <100 meters thick
  DMAQ2: dummy variable = 1 if aquifer is 100 - 150 meters thick
  DMAQ3: dummy variable = 1 if aquifer is > 150 meters thick
- QTRACTORHA=Number of Tractor per hectare
- QBULLHA=Number of Bulls per hectare
- QNITRO, QP_2O_5, QK_2O = Quantities of fertilizers (nitrogen, phosphorus and potassium) in tons

Revised model

RICE:

```
Call:
lm(formula = "YRICE ~ HYVRICE+Rainfall1+Rainfall2+GCANCA+NIANCA+
PRICE+DMAQ1+DMAQ2+DMAQ3+QBULLHA+QTRACHA+QNITRO+QP2O5+QK2O",
    data = Excel1)

Residuals:
    Min      1Q  Median      3Q     Max
-1.0813 -0.2572 -0.0637  0.2252  1.7325

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  9.267e-01  2.257e-01   4.106 5.43e-05 ***
HYVRICE     -1.038e-03  8.432e-04  -1.232 0.219245
Rainfall1   -1.429e-04  7.918e-05  -1.805 0.072227 .
Rainfall2    2.174e-03  3.514e-04   6.188 2.43e-09 ***
GCANCA      -2.829e-01  1.965e-01  -1.440 0.151211
NIANCA       6.659e-02  1.850e-01   0.360 0.719143
PRICE       -3.319e-04  8.868e-04  -0.374 0.708509
DMAQ1       -2.986e-01  8.551e-02  -3.492 0.000566 ***
DMAQ2       -1.022e-01  6.927e-02  -1.475 0.141453
DMAQ3        3.696e-02  1.074e-01   0.344 0.731064
QBULLHA      2.611e-01  7.917e-02   3.299 0.001110 **
QTRACHA      3.429e+01  2.128e+01   1.612 0.108287
QNITRO       3.497e-05  8.918e-06   3.921 0.000113 ***
QP2O5        4.283e-07  2.153e-05   0.020 0.984142
QK2O         4.056e-06  3.883e-05   0.104 0.916873
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3898 on 254 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.5099,    Adjusted R-squared:  0.4829
F-statistic: 18.88 on 14 and 254 DF,  p-value: < 2.2e-16
```

BAJRA:

```
Call:
lm(formula = "YBAJRA ~ HYVBAJRA+Rainfall1+Rainfall2+GCANCA+NIANCA+
PRICE+DMAQ1+DMAQ2+DMAQ3+QBULLHA+QTRACHA+QNITRO+QP2O5+QK2O",
    data = Excel1)

Residuals:
    Min      1Q  Median      3Q     Max
-0.8415 -0.2274 -0.0394  0.1808  3.5239

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  8.039e-01  2.203e-01   3.650 0.000319 ***
HYVBAJRA     3.788e-03  1.583e-03   2.393 0.017438 *
Rainfall1   -2.317e-04  7.968e-05  -2.908 0.003963 **
Rainfall2   -5.147e-04  3.434e-04  -1.499 0.135138
GCANCA      -4.802e-02  1.936e-01  -0.248 0.804273
NIANCA       4.837e-01  1.829e-01   2.644 0.008702 **
PRICE       -2.599e-03  8.768e-04  -2.964 0.003321 **
DMAQ1        1.429e-01  8.526e-02   1.676 0.094986 .
DMAQ2        1.949e-01  6.824e-02   2.856 0.004649 **
DMAQ3       -6.200e-02  1.069e-01  -0.580 0.562458
QBULLHA     -9.732e-02  7.948e-02  -1.225 0.221880
QTRACHA      3.598e+01  2.117e+01   1.699 0.090495 .
QNITRO       1.542e-06  8.748e-06   0.176 0.860207
QP2O5        1.833e-05  2.117e-05   0.866 0.387370
QK2O        -1.535e-05  3.470e-05  -0.442 0.658545
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.388 on 254 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.2997,    Adjusted R-squared:  0.2611
F-statistic: 7.766 on 14 and 254 DF,  p-value: 1.24e-13
```

Revised model

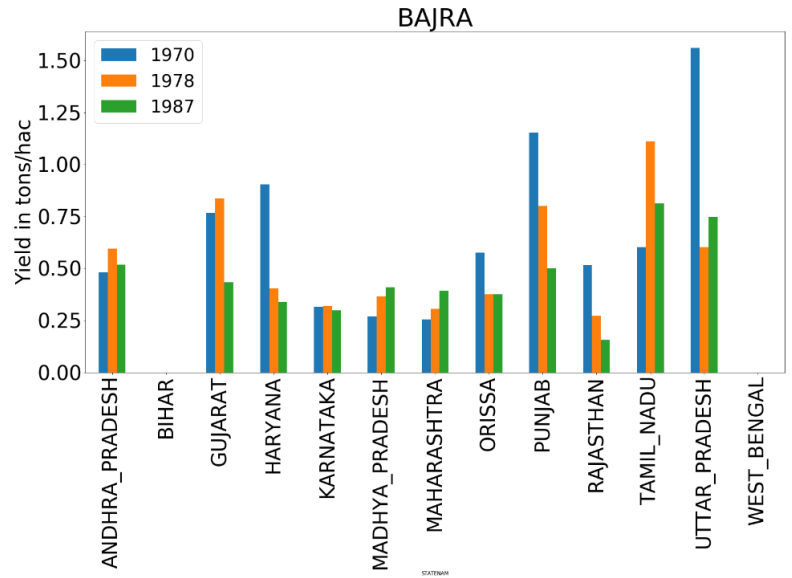
Maize:

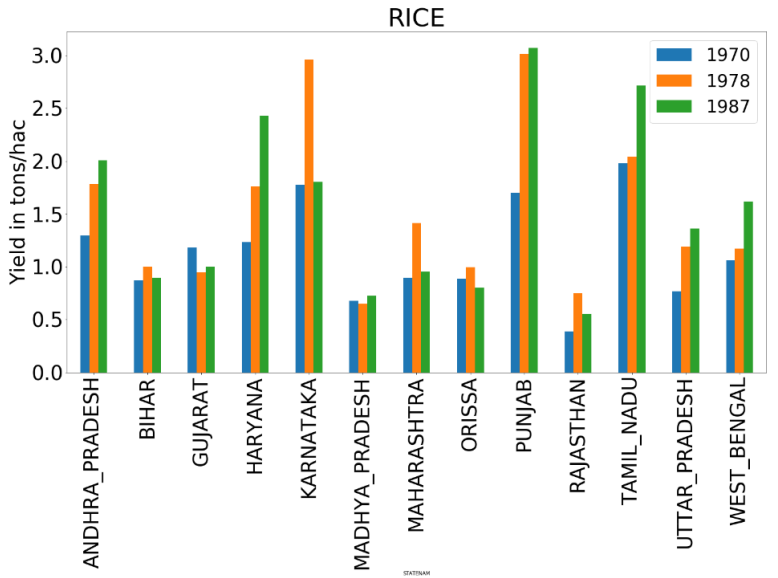
```
Call:
lm(formula = "YMAIZE ~ HYVMAIZE+Rainfall1+Rainfall2+GCANCA+NIANCA+
PRICE+DMAQ1+DMAQ2+DMAQ3+QBULLHA+QTRACHA+QNITRO+QP2O5+QK2O",
    data = Excel1)

Residuals:
    Min      1Q  Median      3Q     Max
-1.4797 -0.3600 -0.0334  0.2934  2.8099

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.839e+00  3.523e-01   5.220 3.73e-07 ***
HYVMAIZE     5.877e-02  1.412e-02   4.161 4.34e-05 ***
Rainfall1   -1.160e-04  1.270e-04  -0.913  0.36193
Rainfall2   -1.405e-04  5.446e-04  -0.258  0.79665
GCANCA      -9.212e-01  3.133e-01  -2.940  0.00358 **
NIANCA       6.211e-01  2.945e-01   2.109  0.03595 *
PRICE       -8.100e-05  1.414e-03  -0.057  0.95436
DMAQ1       -3.991e-01  1.380e-01  -2.892  0.00416 **
DMAQ2       -8.447e-02  1.103e-01  -0.766  0.44438
DMAQ3       -8.536e-02  1.730e-01  -0.493  0.62210
QBULLHA      5.366e-01  1.291e-01   4.158 4.39e-05 ***
QTRACHA      1.049e+01  3.430e+01   0.306  0.76007
QNITRO       1.136e-05  1.429e-05   0.795  0.42714
QP2O5        3.978e-05  3.414e-05   1.165  0.24501
QK2O        -1.624e-04  5.617e-05  -2.891  0.00417 **
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.6266 on 254 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.2483,    Adjusted R-squared:  0.2068
F-statistic: 5.992 on 14 and 254 DF,  p-value: 3.387e-10
```

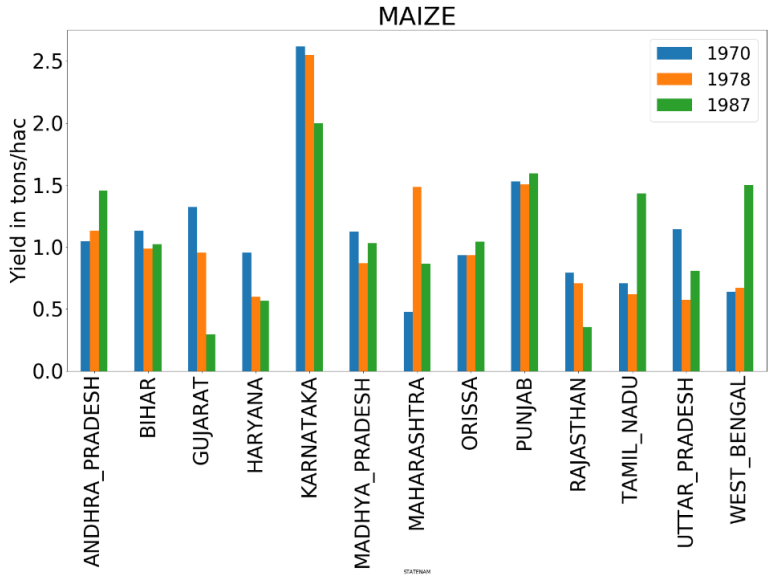
Jowar:

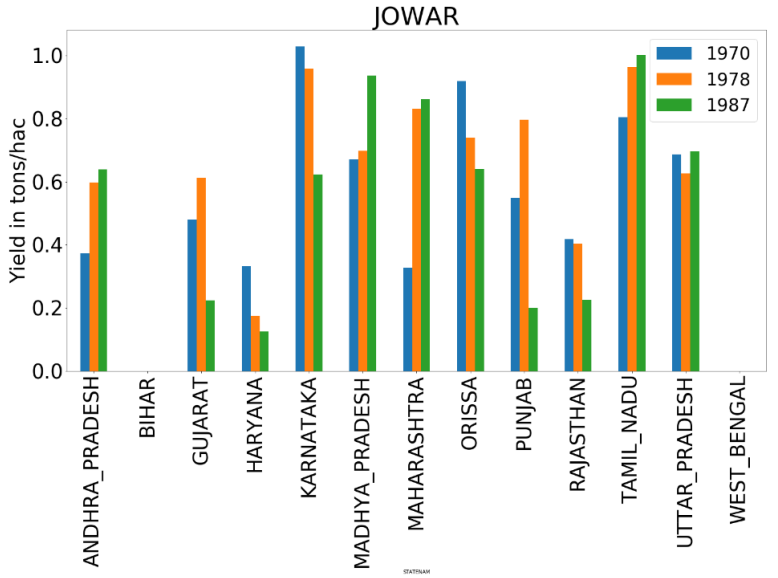
```
Call:
lm(formula = "YJOWAR ~ HYVJOWAR+Rainfall1+Rainfall2+GCANCA+NIANCA+
PRICE+DMAQ1+DMAQ2+DMAQ3+QBULLHA+QTRACHA+QNITRO+QP2O5+QK2O",
    data = Excel1)

Residuals:
     Min       1Q   Median       3Q      Max
-0.87753 -0.24348 -0.04375  0.19951  2.26510

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  9.109e-01  2.448e-01   3.722 0.000244 ***
HYVJOWAR    -1.013e-03  3.237e-03  -0.313 0.754713
Rainfall1   -2.041e-04  8.675e-05  -2.353 0.019393 *
Rainfall2    5.084e-04  3.728e-04   1.364 0.173865
GCANCA      -3.688e-02  2.140e-01  -0.172 0.863326
NIANCA       3.464e-02  2.027e-01   0.171 0.864423
PRICE       -2.942e-03  9.645e-04  -3.050 0.002529 **
DMAQ1       -9.583e-02  9.396e-02  -1.020 0.308784
DMAQ2       -7.756e-02  7.597e-02  -1.021 0.308248
DMAQ3       -3.884e-01  1.181e-01  -3.289 0.001148 **
QBULLHA      1.322e-01  8.813e-02   1.500 0.134859
QTRACHA      9.182e+01  2.332e+01   3.938 0.000106 ***
QNITRO      -2.037e-05  9.612e-06  -2.120 0.035017 *
QP2O5        1.703e-06  2.329e-05   0.073 0.941760
QK2O         6.412e-05  3.921e-05   1.635 0.103252
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4275 on 254 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.178,     Adjusted R-squared:  0.1327
F-statistic:  3.93 on 14 and 254 DF,  p-value: 4.223e-06
```

Yield for crop year wise

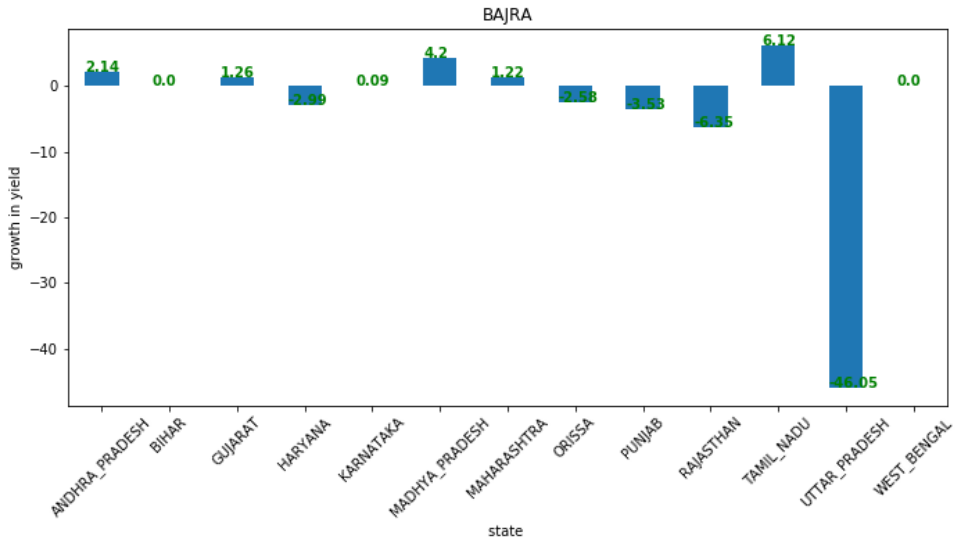


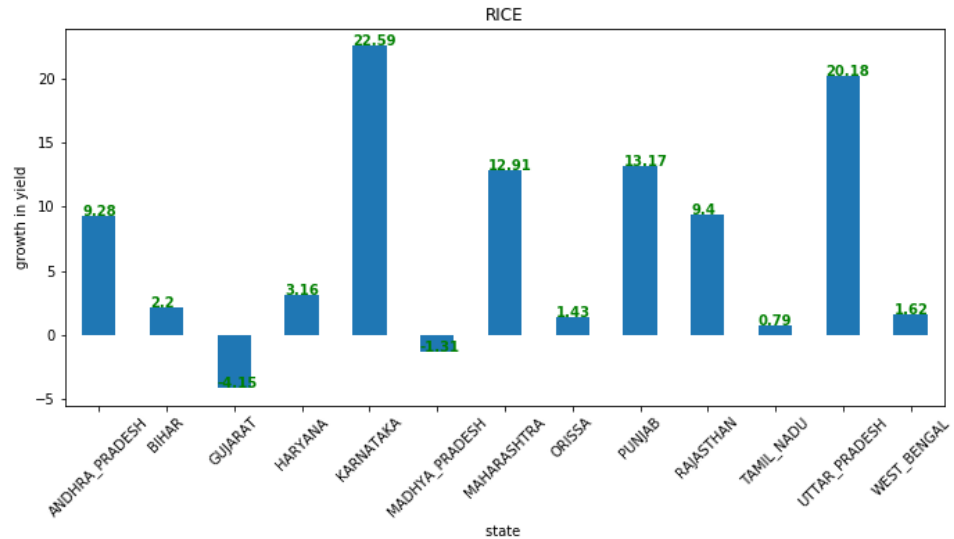


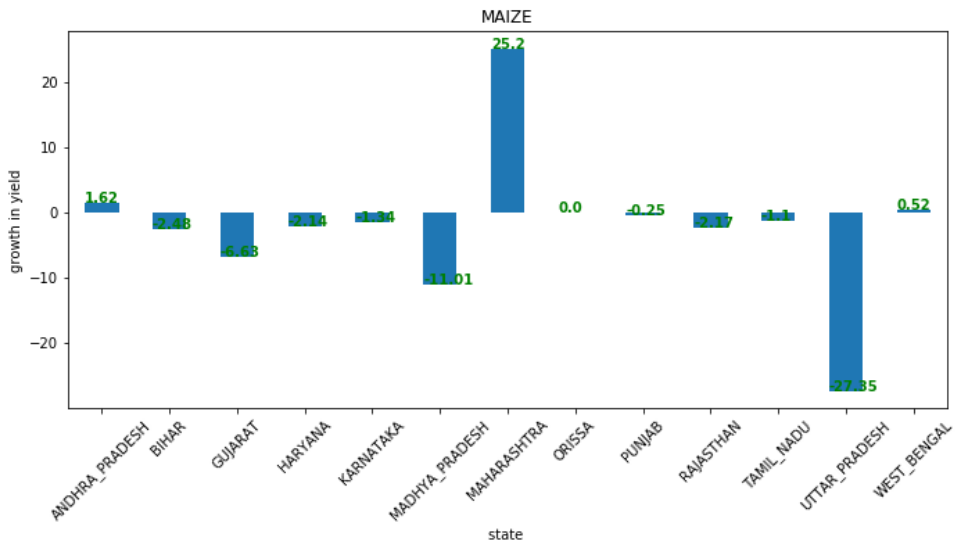


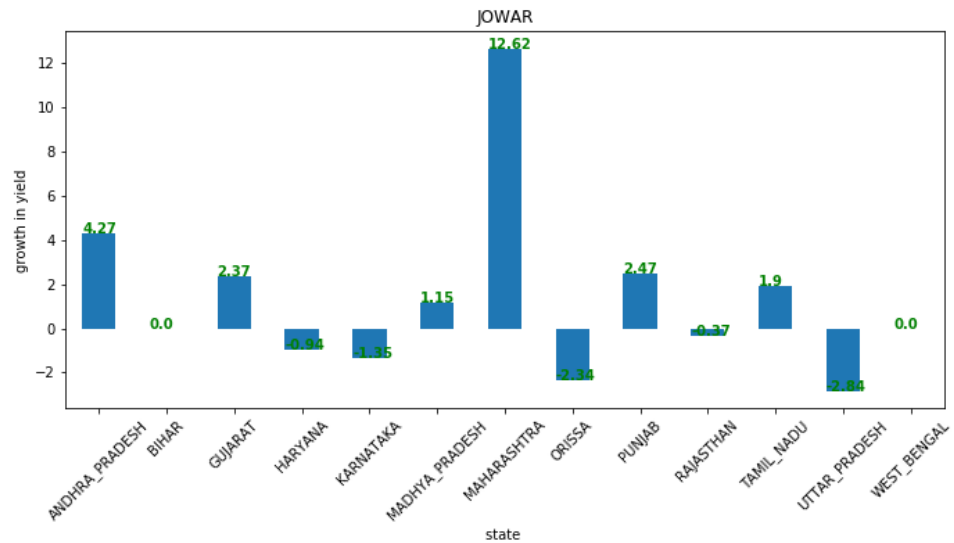


Yield growth in 1978 comapred to 1970

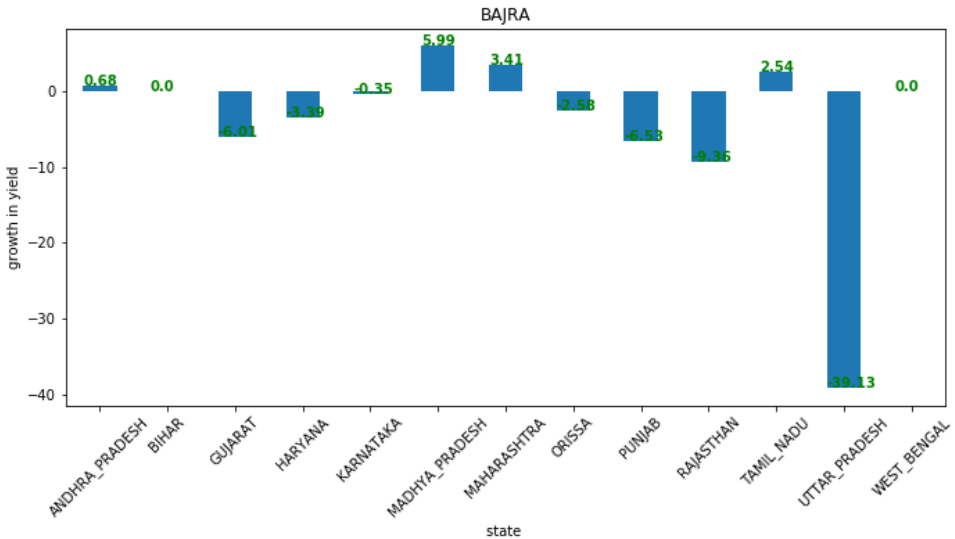


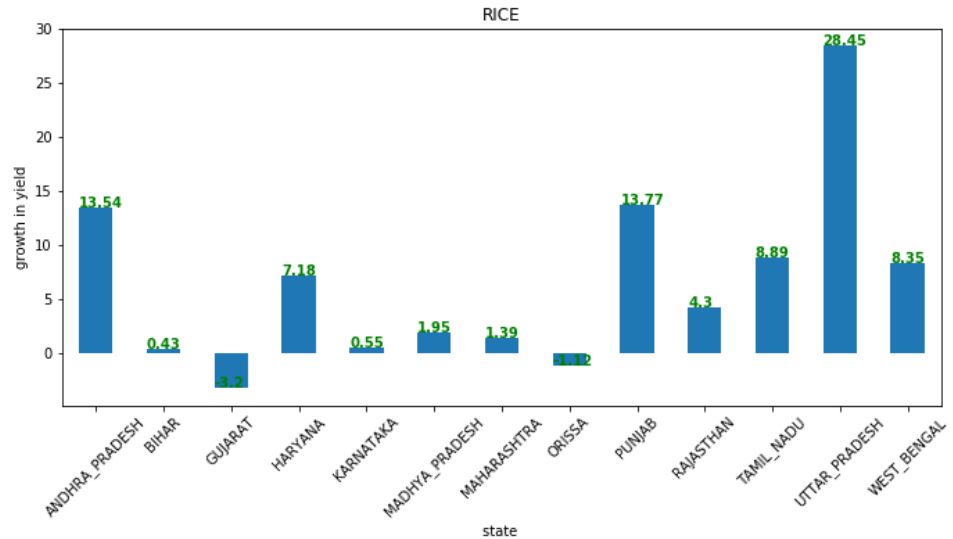


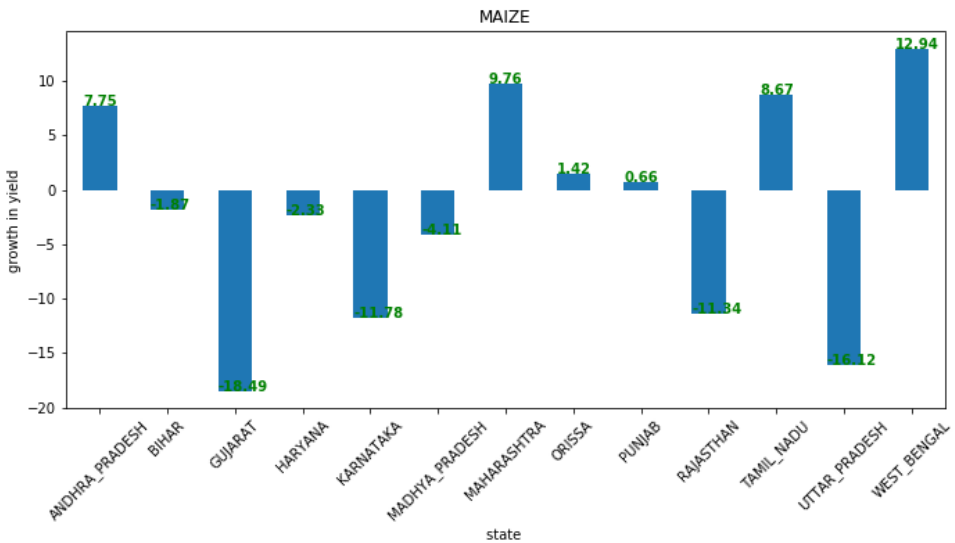


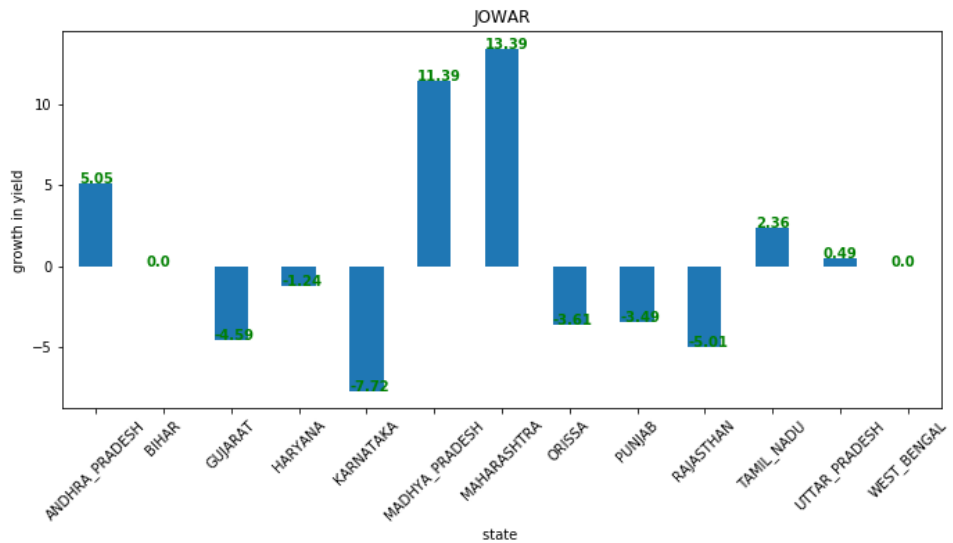


Yield growth in 1987 comapred to 1970



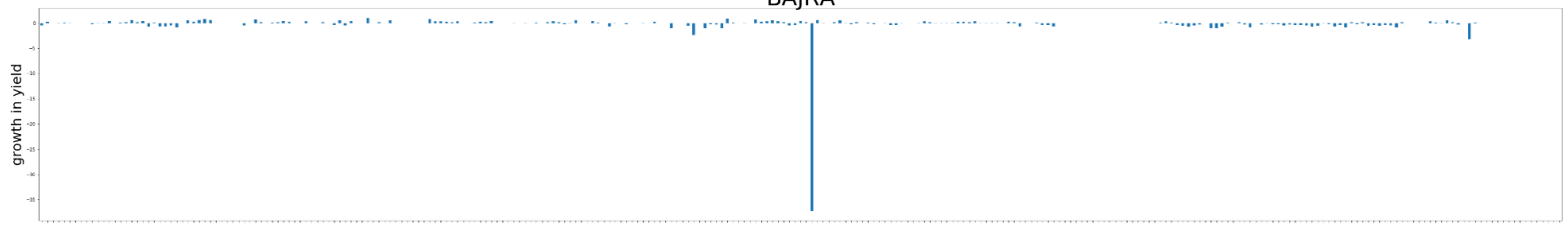




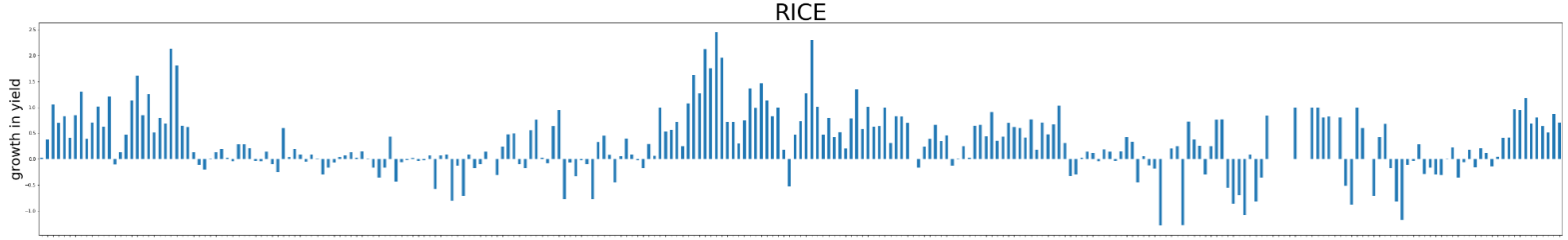


Growth Yield in 1987 compared to 1970

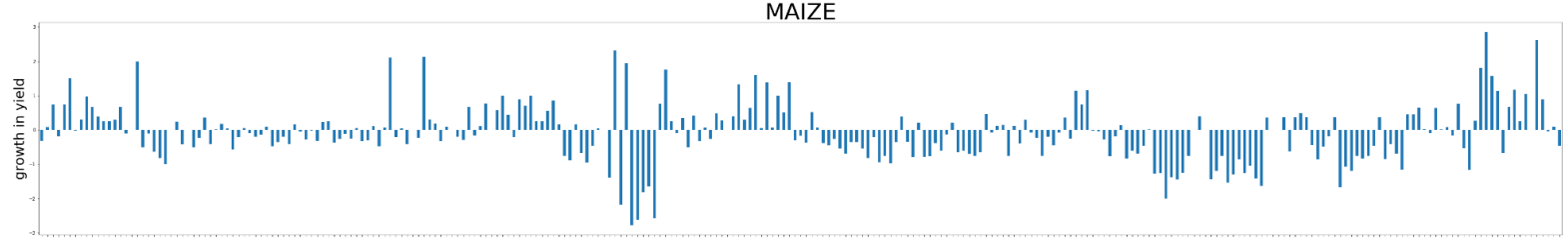
BAJRA



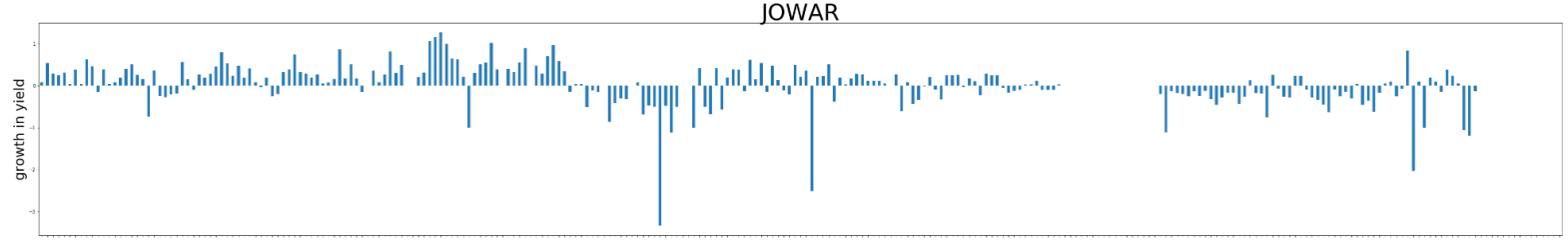
RICE

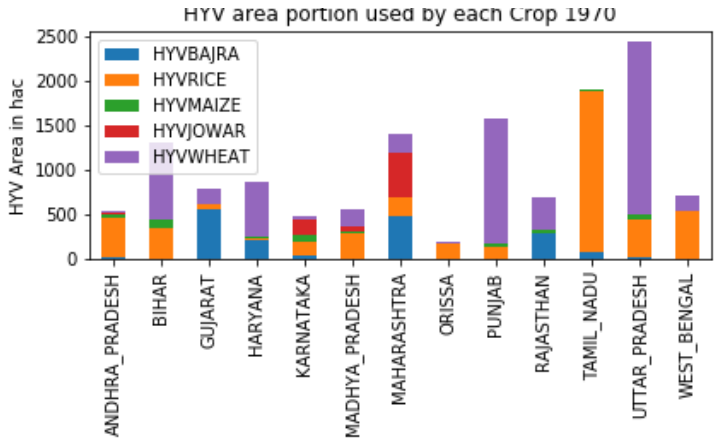


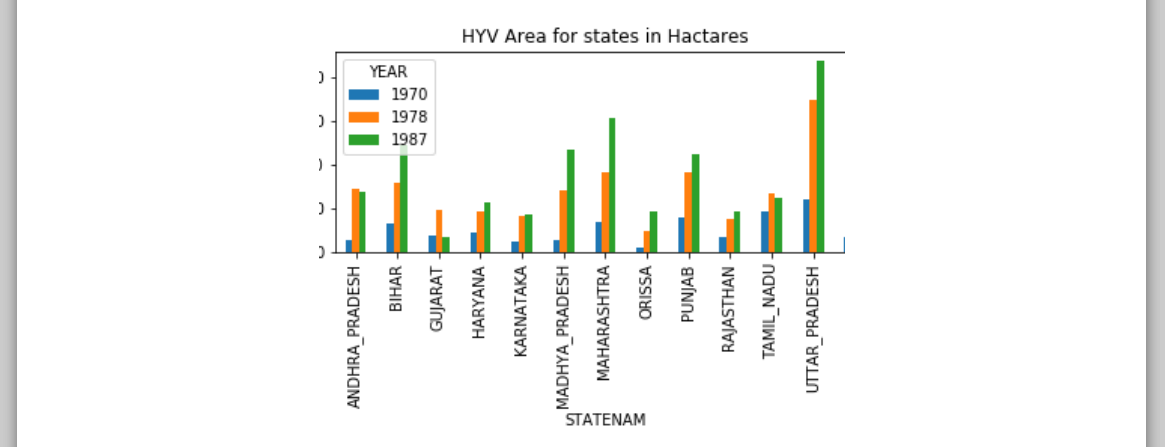
MAIZE

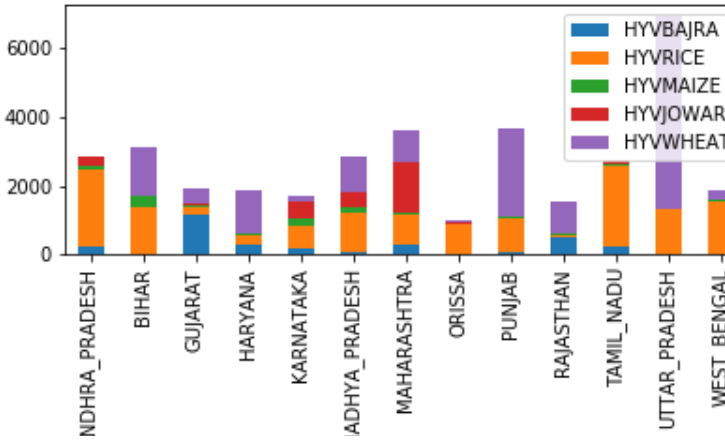


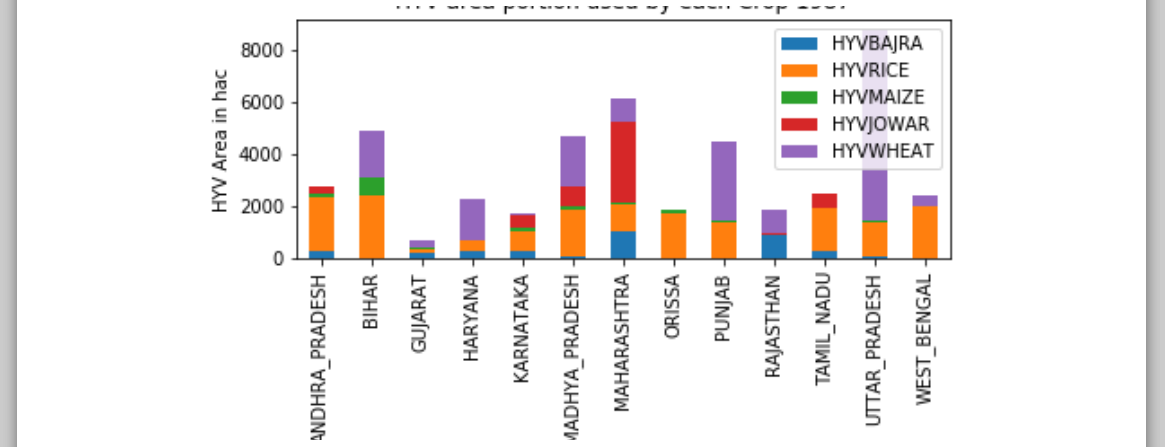
JOWAR

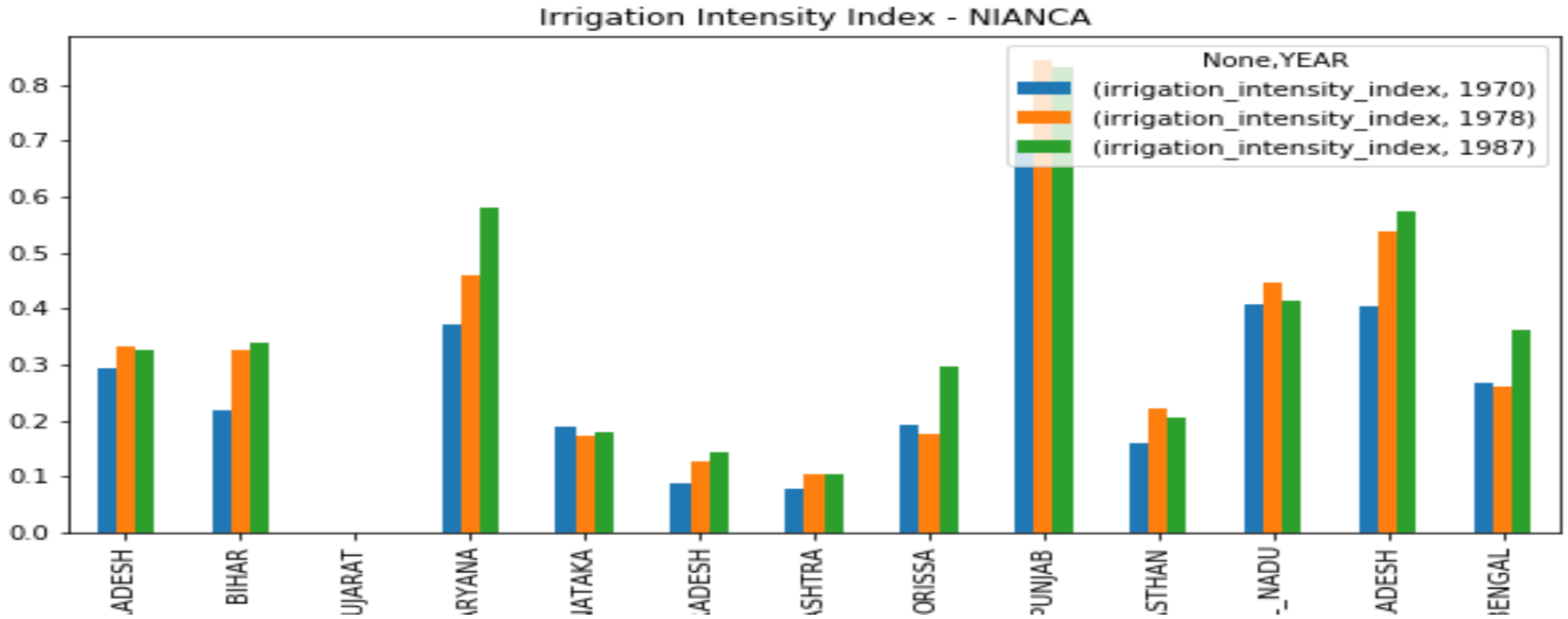


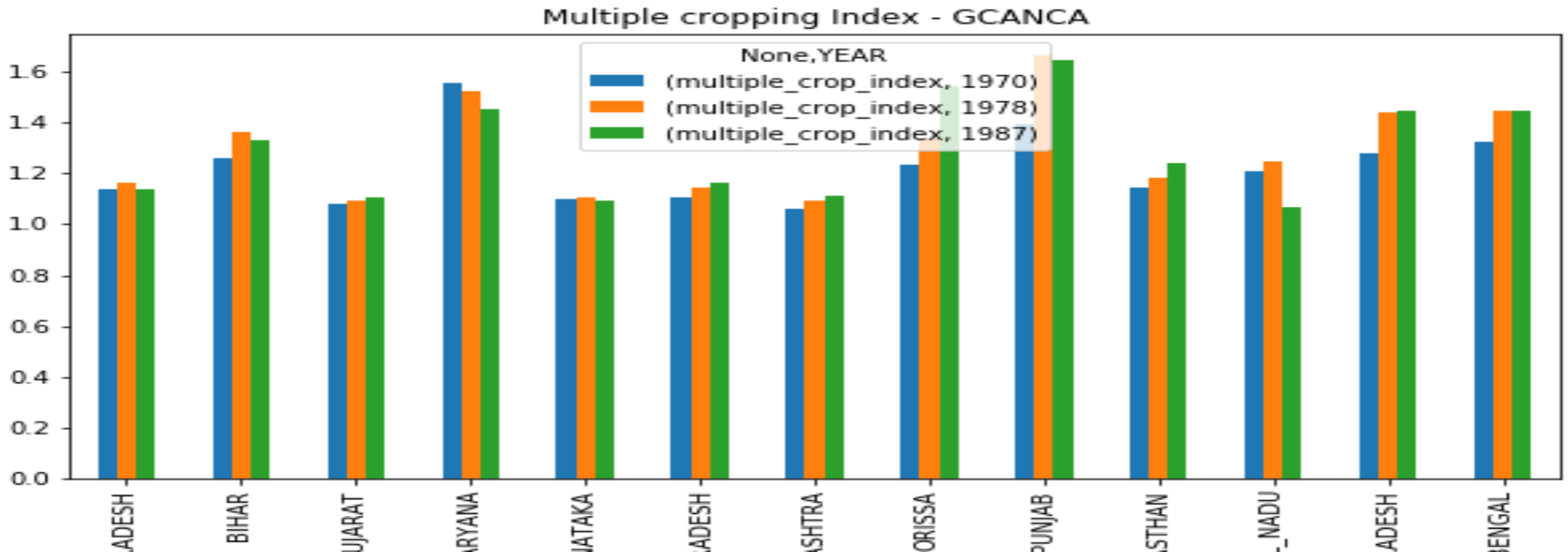

HYV area portion used by each Crop 1970
HYV Area in hac
2500
2000
1500
1000
500
0
HYVBAJRA
HYVRICE
HYVMAIZE
HYVJOWAR
HYVWHEAT
ANDHRA_PRADESH
BIHAR
GUJARAT
HARYANA
KARNATAKA
MADHYA_PRADESH
MAHARASHTRA
ORISSA
PUNJAB
RAJASTHAN
TAMIL_NADU
UTTAR_PRADESH
WEST_BENGAL


HYV Area for states in Hactares
YEAR
1970
1978
1987
ANDHRA_PRADESH
BIHAR
GUJARAT
HARYANA
KARNATAKA
MADHYA_PRADESH
MAHARASHTRA
ORISSA
PUNJAB
RAJASTHAN
TAMIL_NADU
UTTAR_PRADESH
STATENAM

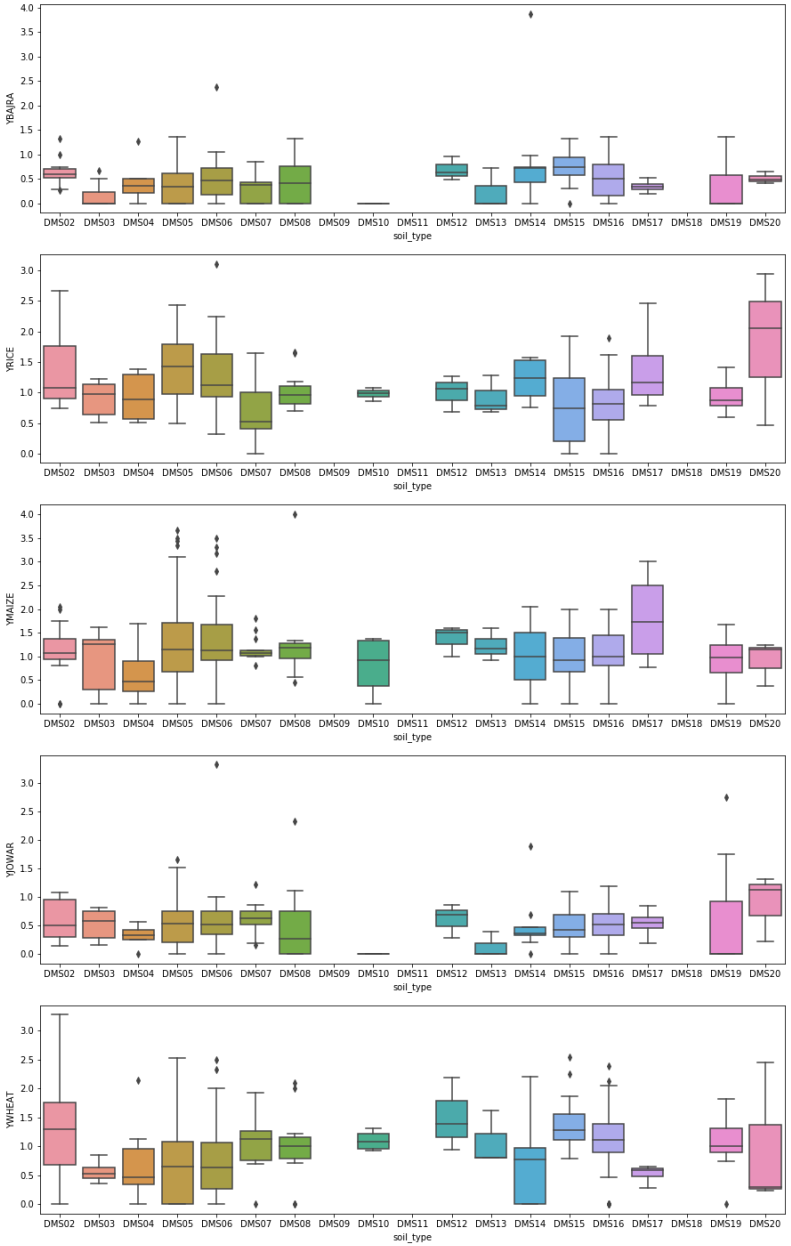

HYV Area in hac
6000
4000
2000
0
HYVBAJRA
HYVRICE
HYVMAIZE
HYVJOWAR
HYVWHEAT
BIHAR
GUJARAT
HARYANA
KARNATAKA
MAHARASHTRA
ORISSA
PUNJAB
RAJASTHAN
TAMIL_NADU
UTTAR_PRADESH
WEST_BENGAL


HYV Area in hac
8000
6000
4000
2000
0
HYVBAJRA
HYVRICE
HYVMAIZE
HYVJOWAR
HYVWHEAT
BIHAR
GUJARAT
HARYANA
KARNATAKA
MAHARASHTRA
ORISSA
PUNJAB
RAJASTHAN
TAMIL_NADU
UTTAR_PRADESH
WEST_BENGAL

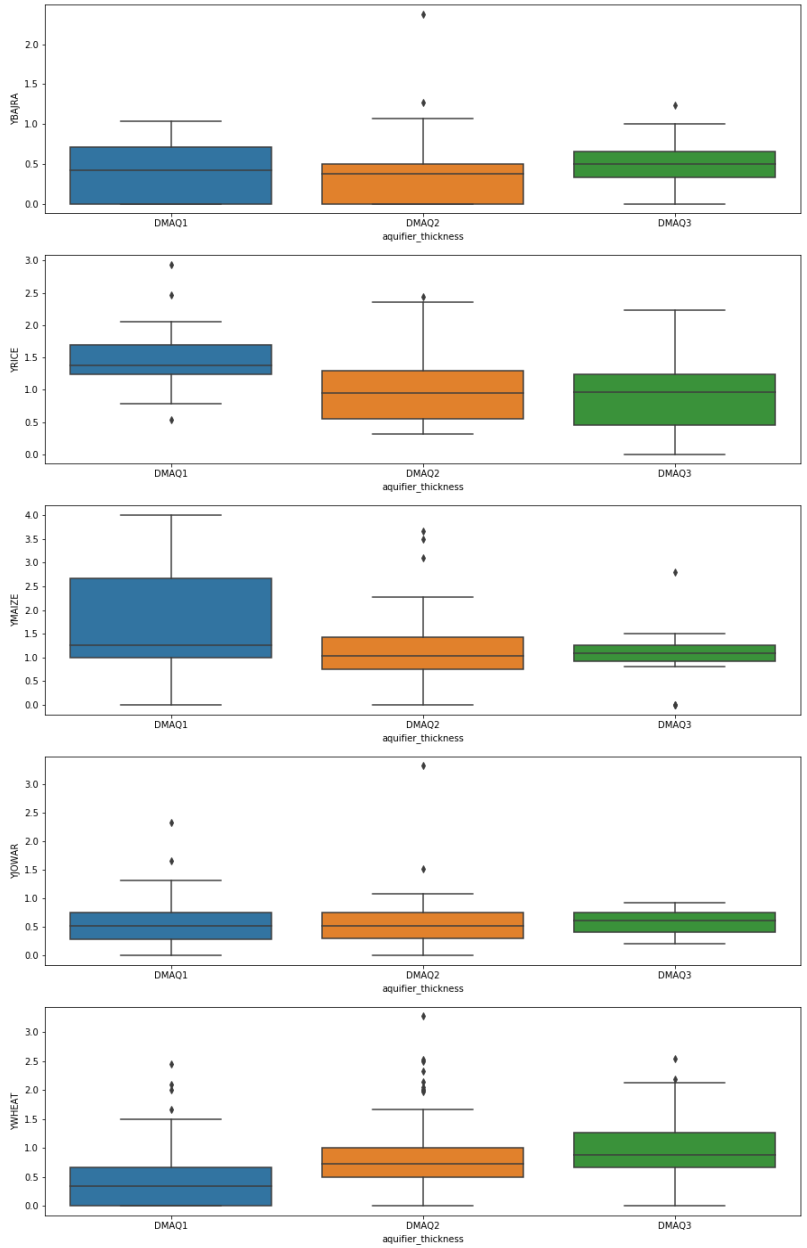

Irrigation Intensity Index - NIANCA
None,YEAR
(irrigation_intensity_index, 1970)
(irrigation_intensity_index, 1978)
(irrigation_intensity_index, 1987)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
ADESH
BIHAR
UJARAT
RYANA
ATAKA
ADESH
SHTRA
ORISSA
UNJAB
STHAN
_NADU
ADESH
ENGAL


Multiple cropping Index - GCANCA
None,YEAR
(multiple_crop_index, 1970)
(multiple_crop_index, 1978)
(multiple_crop_index, 1987)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
ADESH
BIHAR
UJARAT
RYANA
ATAKA
ADESH
SHTRA
ORISSA
UNJAB
STHAN
_NADU
ADESH
ENGAL

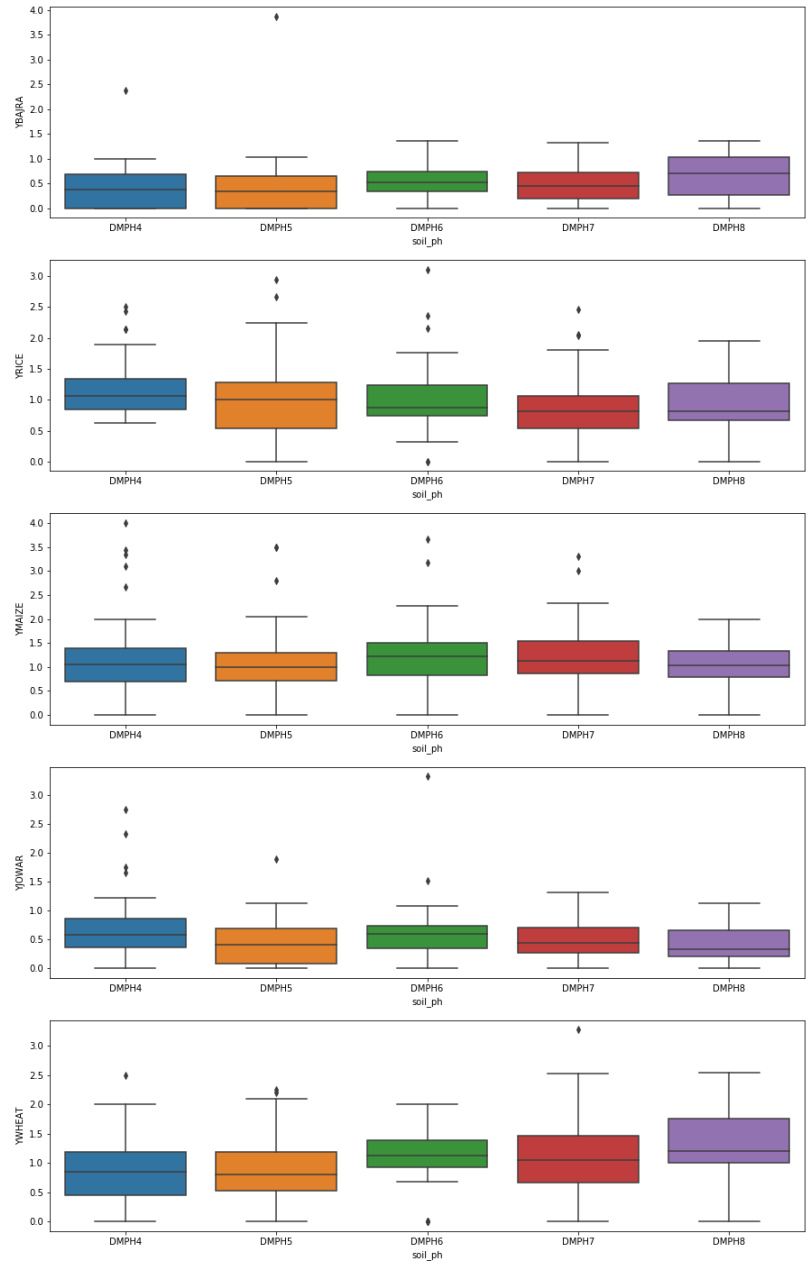
Yield V/s soil_type

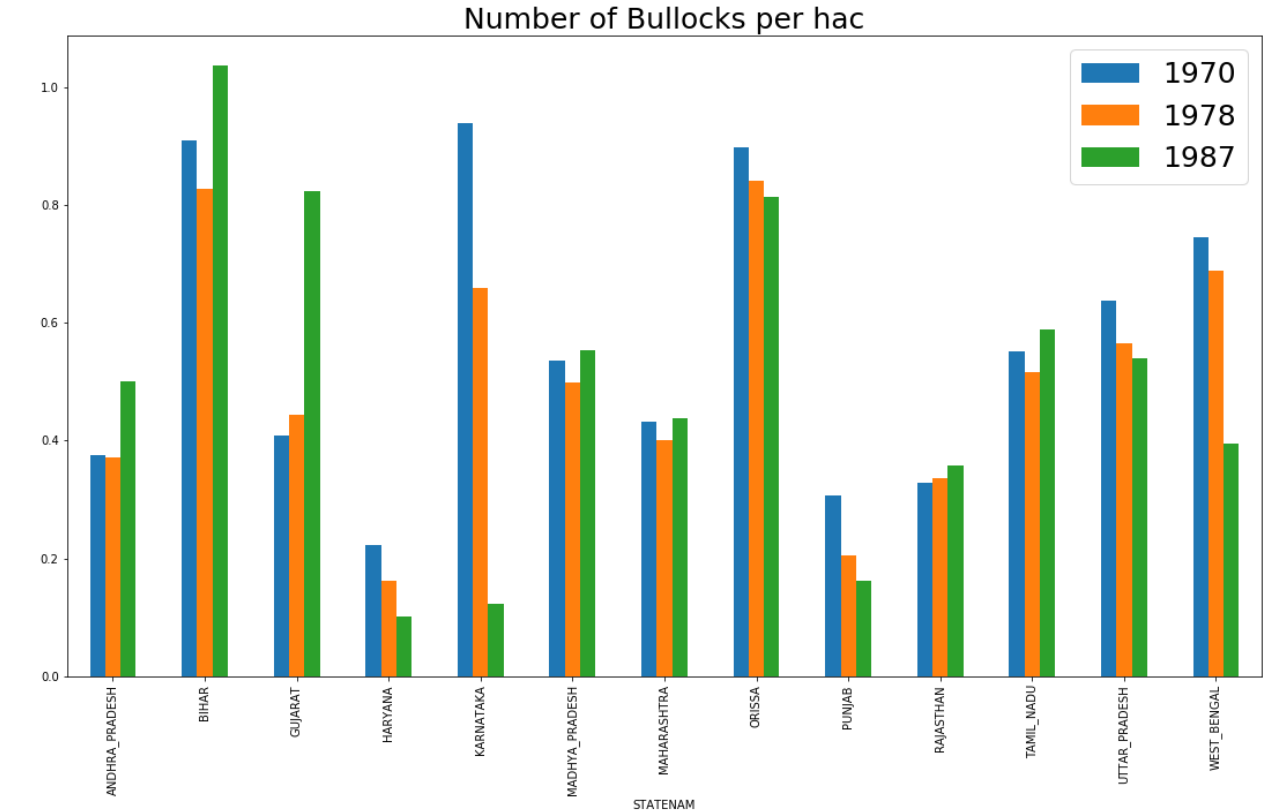


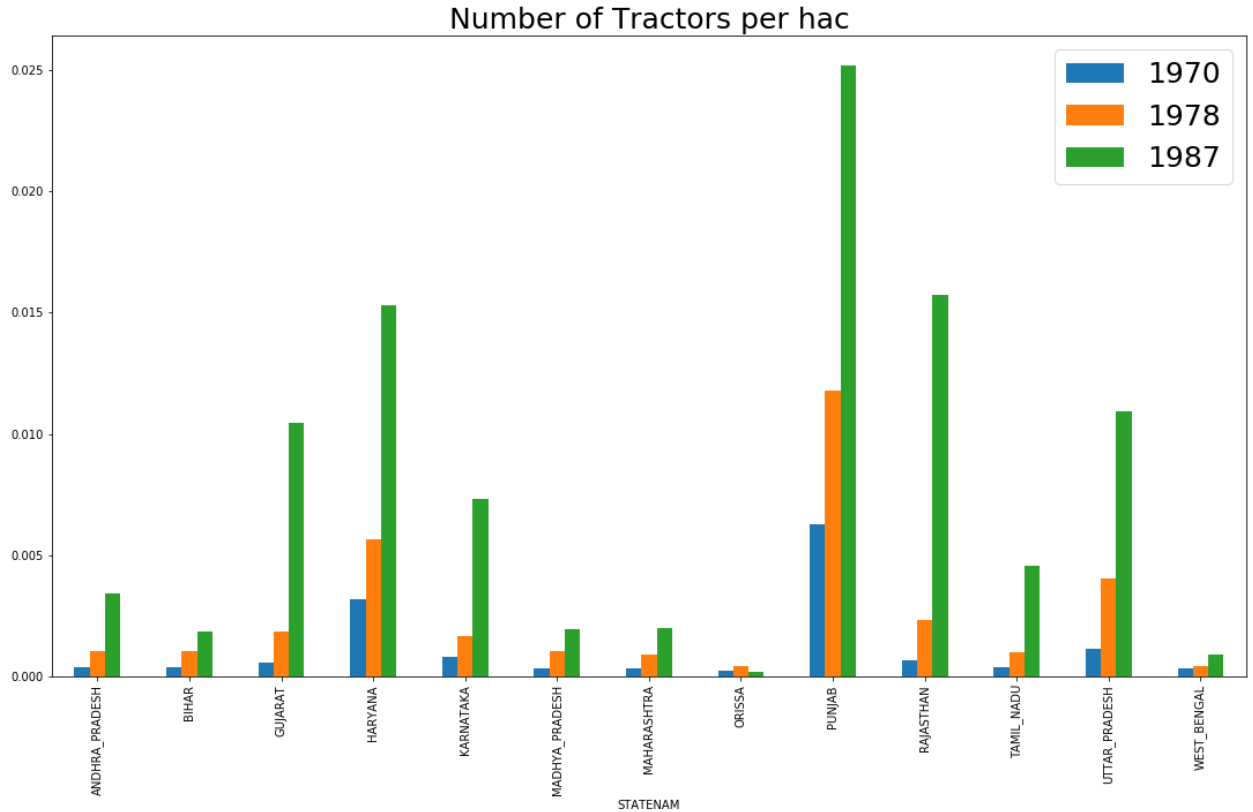
Yield V/s soil_aquifier_thickness



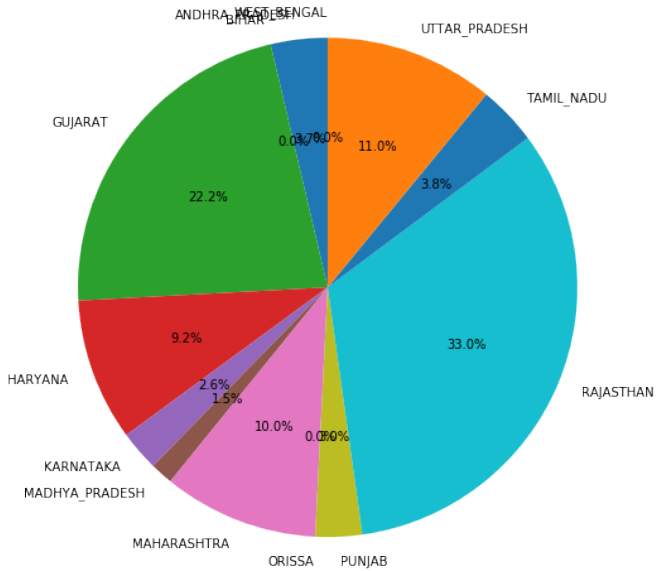
Yield V/s soil_ph



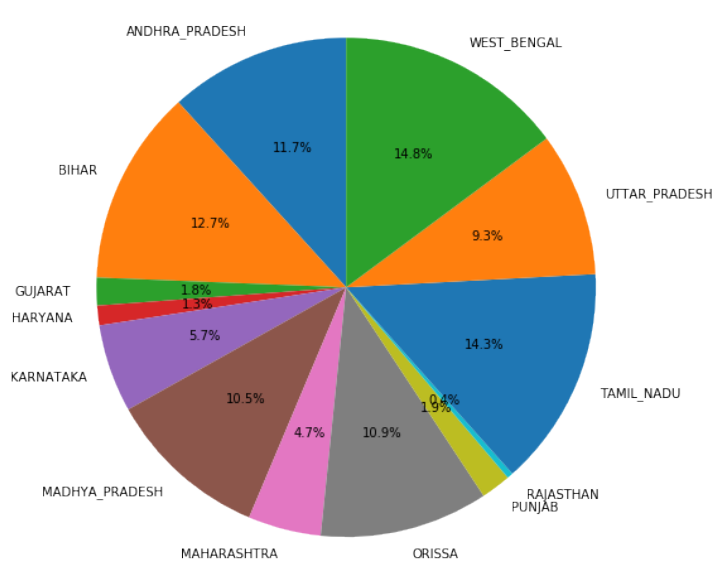

Number of Bullocks per hac
1970
1978
1987
1.0
0.8
0.6
0.4
0.2
0.0
ANDHRA_PRADESH
BIHAR
GUJARAT
HARYANA
KARNATAKA
MADHYA_PRADESH
MAHARASHTRA
ORISSA
PUNJAB
RAJASTHAN
TAMIL_NADU
UTTAR_PRADESH
WEST_BENGAL
STATENAM


Number of Tractors per hac
1970
1978
1987
0.025
0.020
0.015
0.010
0.005
0.000
ANDHRA_PRADESH
BIHAR
GUJARAT
HARYANA
KARNATAKA
MADHYA_PRADESH
MAHARASHTRA
ORISSA
PUNJAB
RAJASTHAN
TAMIL_NADU
UTTAR_PRADESH
WEST_BENGAL
STATENAM

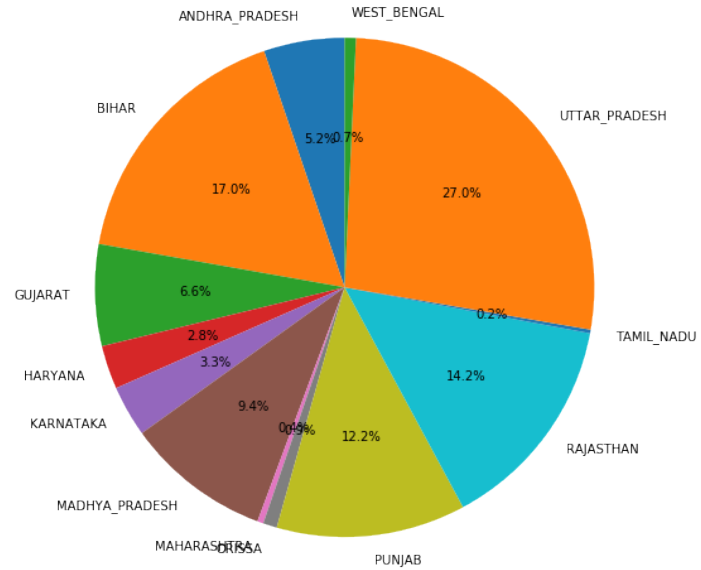
BAJRA



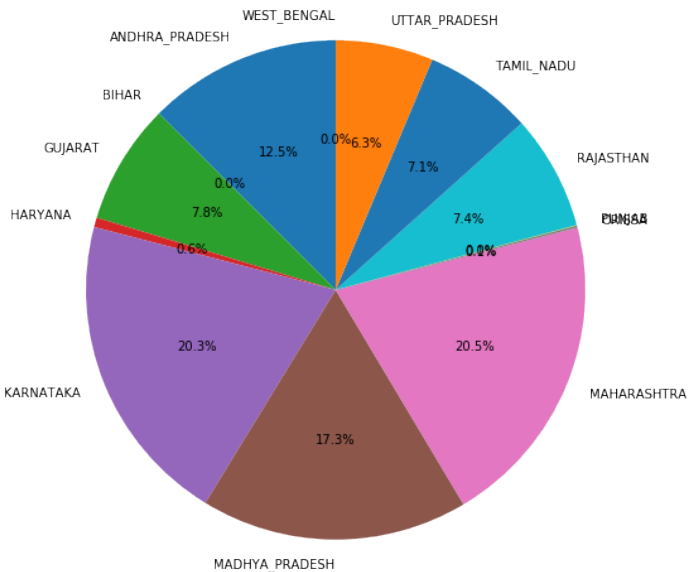
RICE



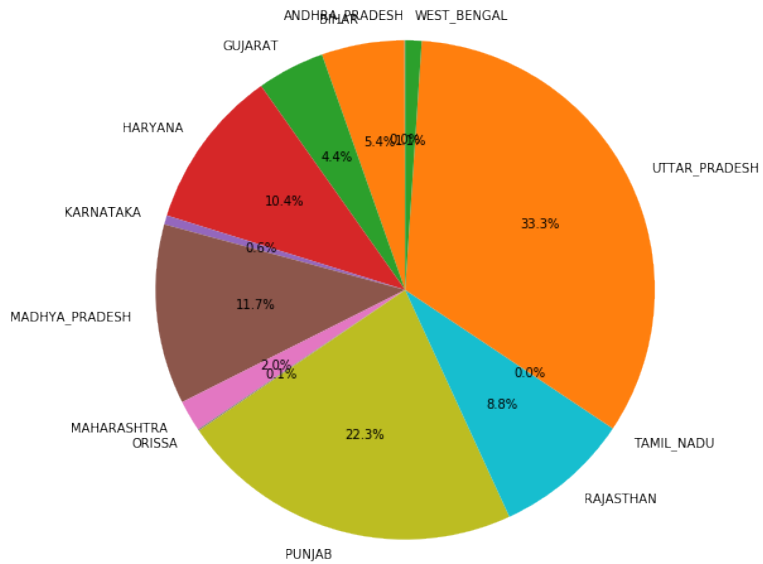
MAIZE



JOWAR

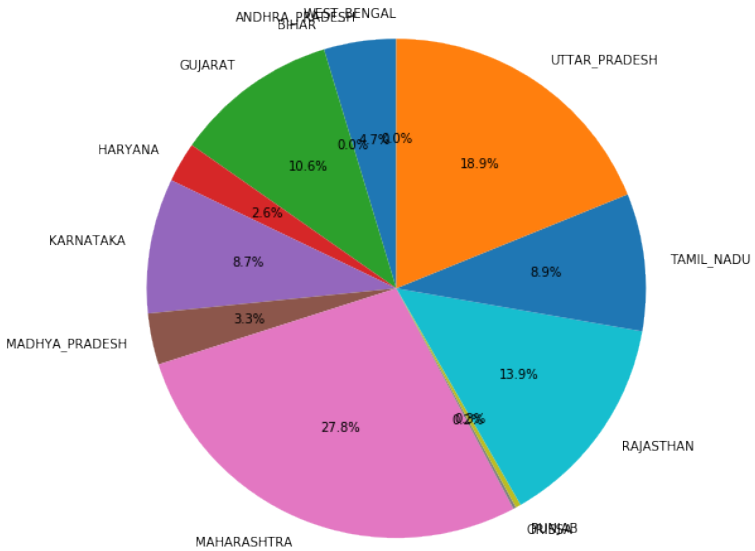


WHEAT

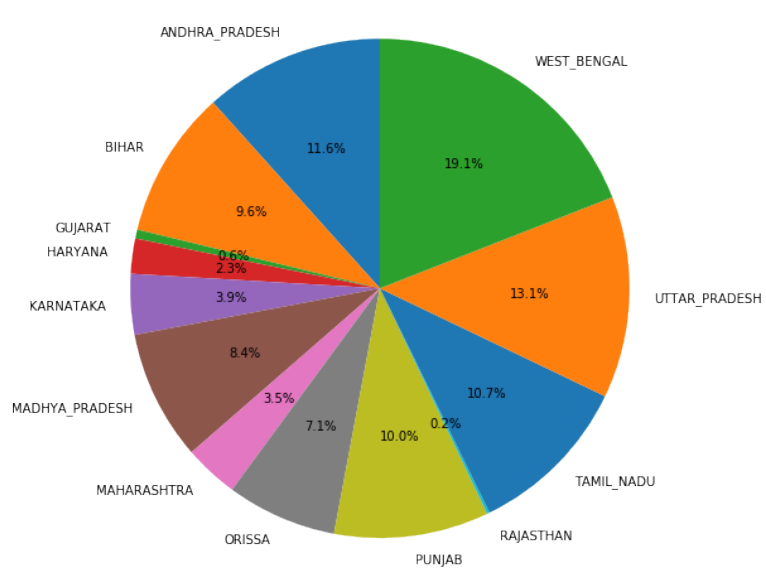


Year 1970

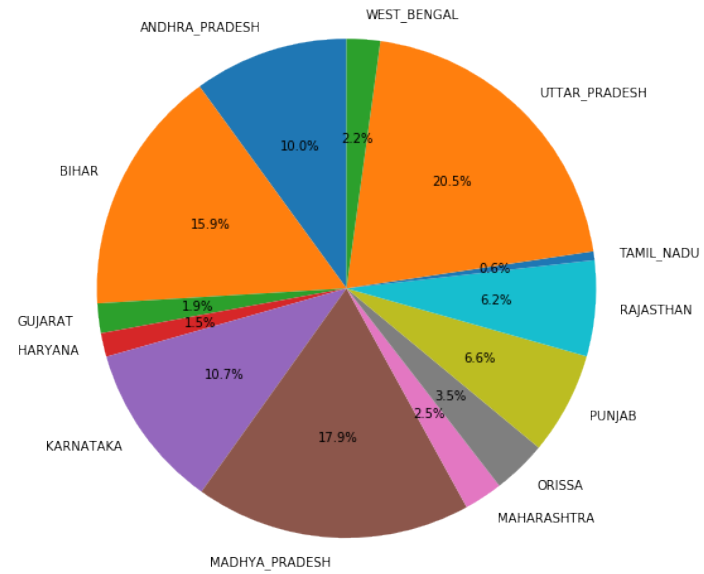
BAJRA



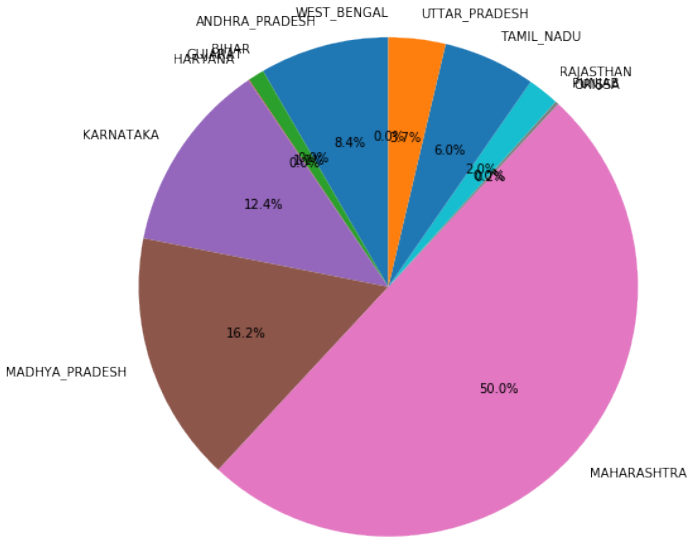
RICE



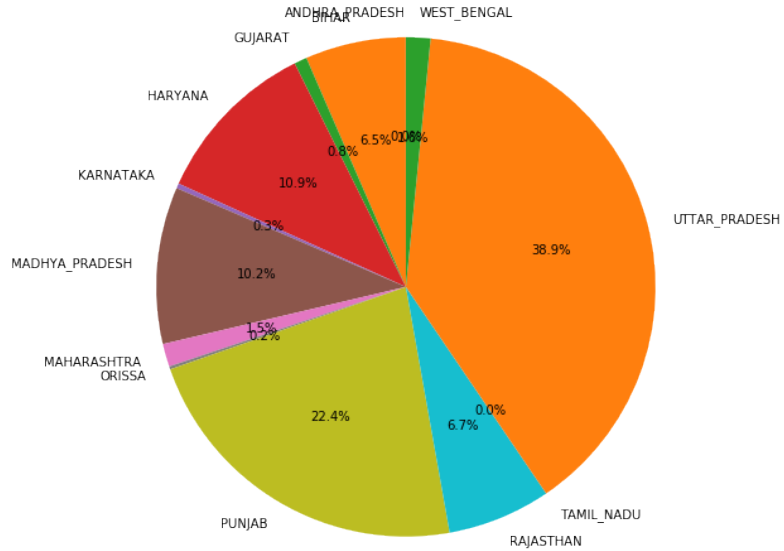
MAIZE



JOWAR

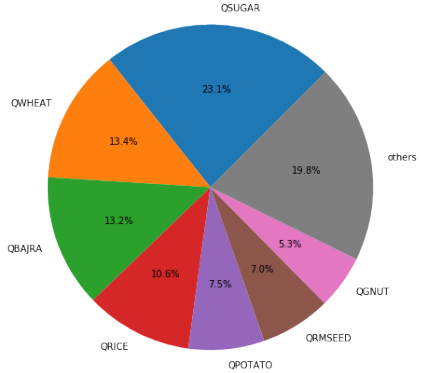


WHEAT

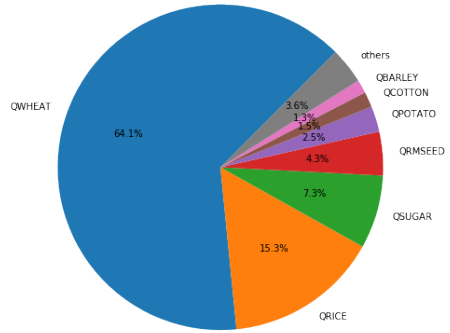


Year 1987

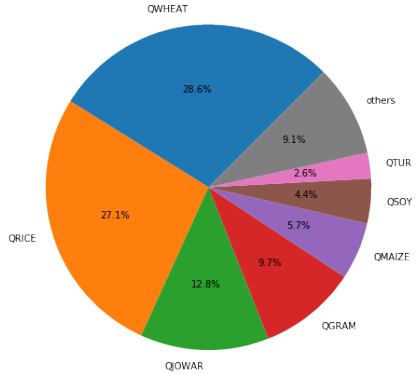
GUJARAT



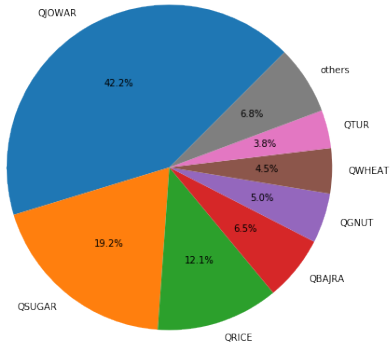
HARYANA



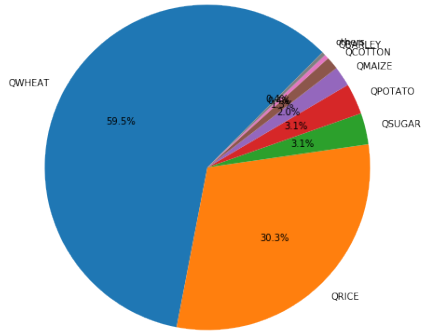
MADHYA_PRADESH



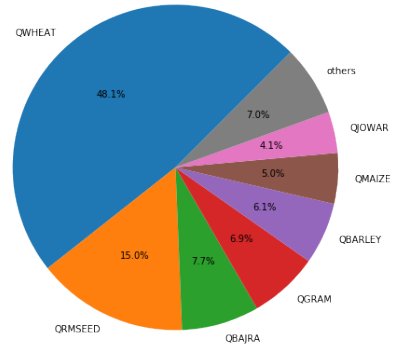
MAHARASHTRA



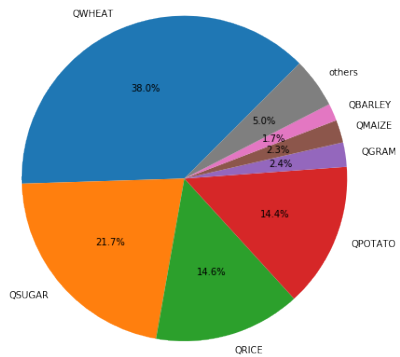
PUNJAB



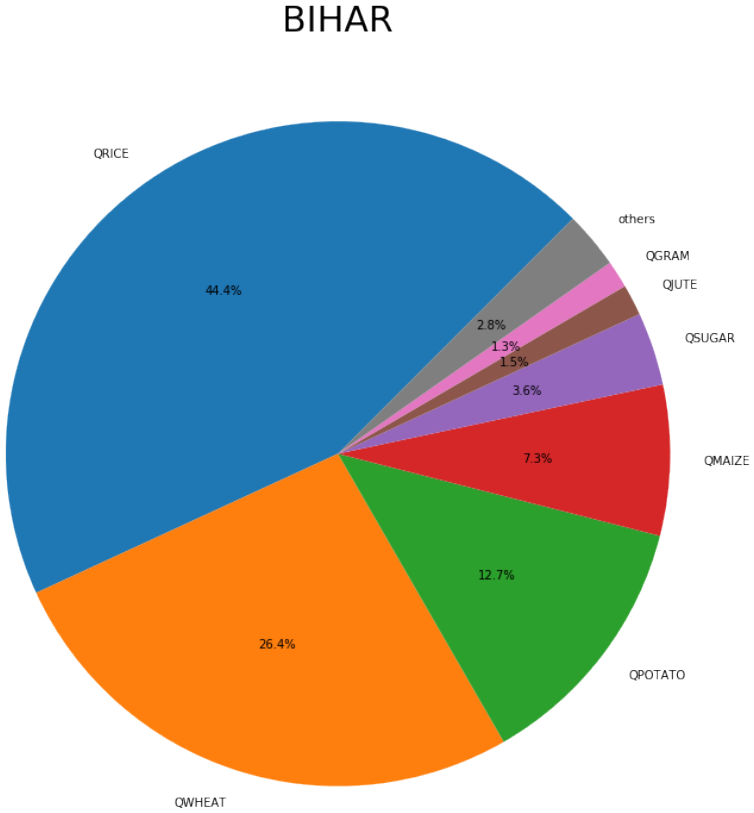
RAJASTHAN

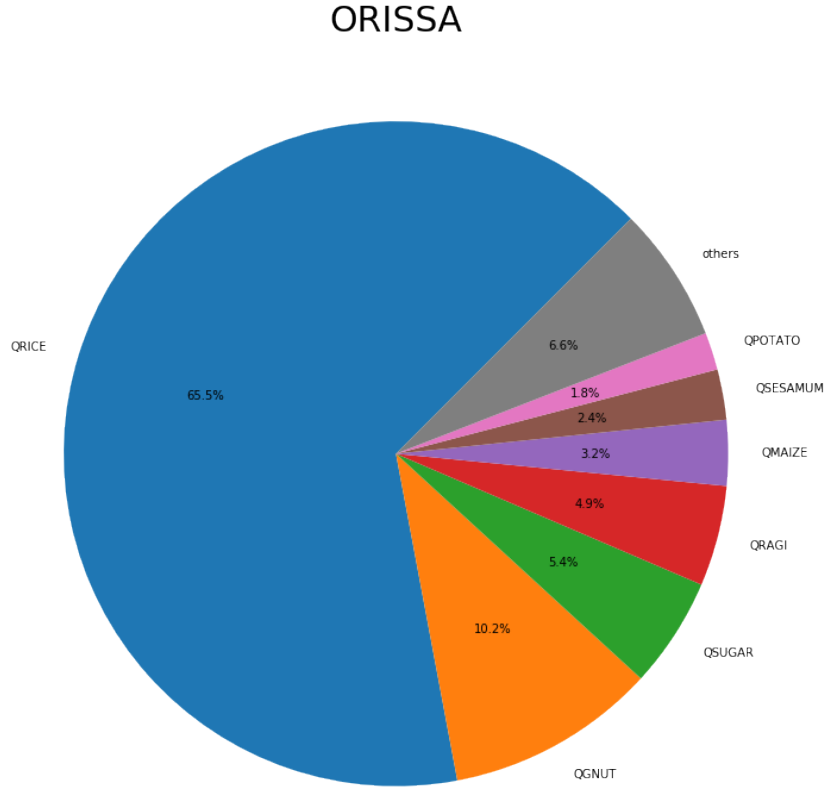


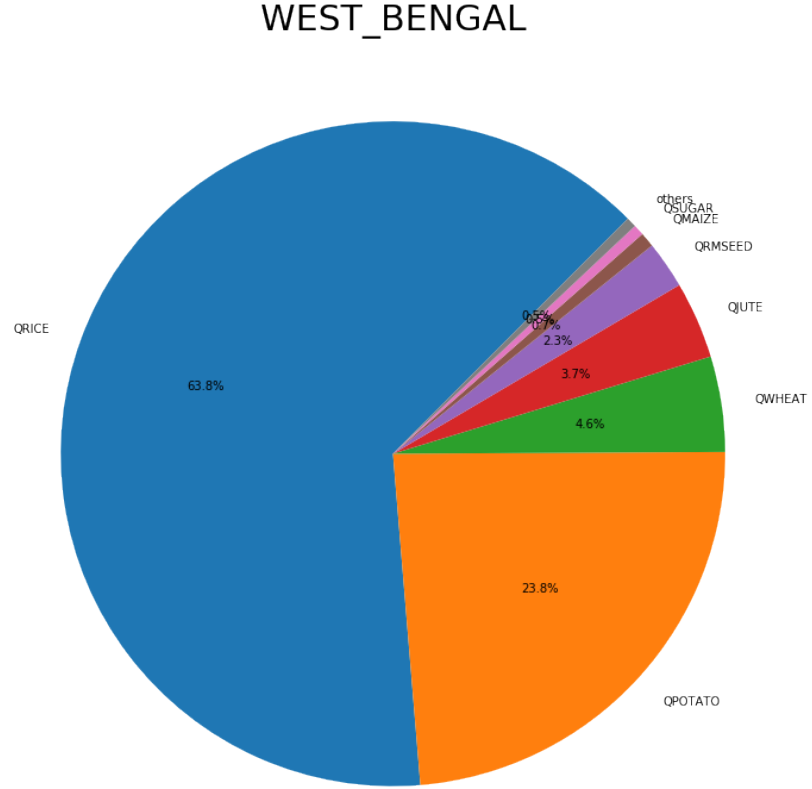
UTTAR_PRADESH



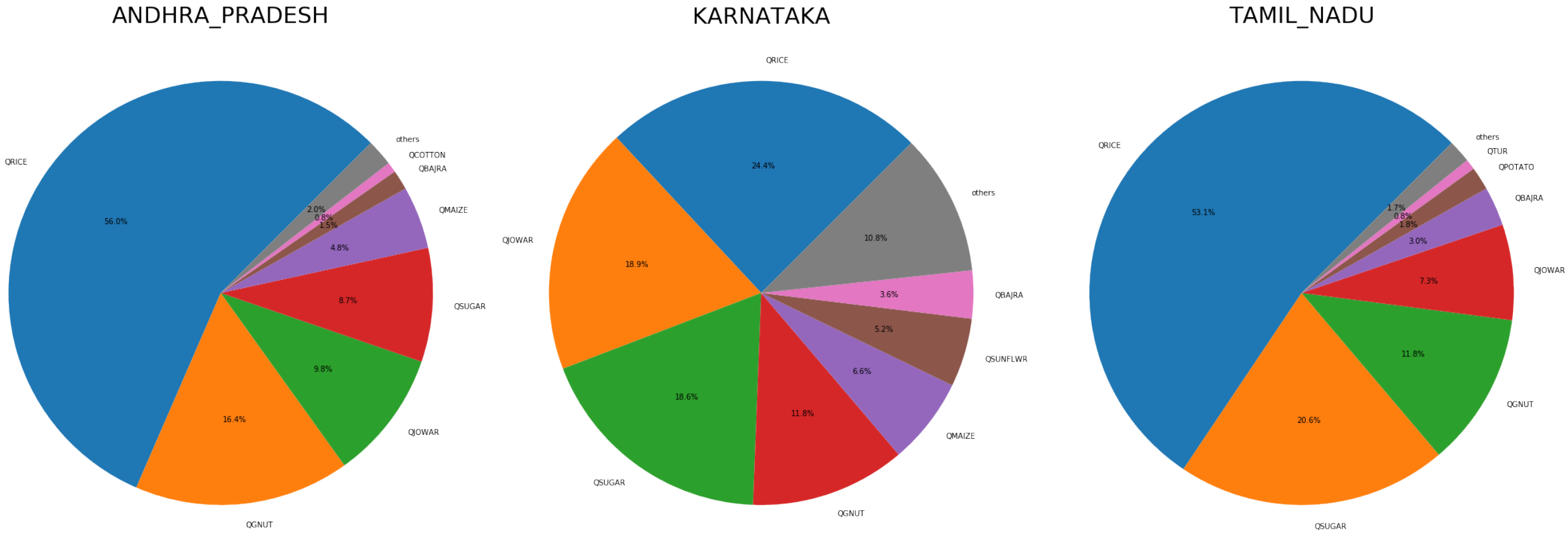
Year 1987, North India







Year 1987, East India



Year 1987, South India