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# Studies on influence of El- Nino rainfall and crop production of major crops in Eastern Uttar Pradesh

**Ajeet Kumar, AK Singh, Amit Kumar, RK Aryan and Kali Deen**

**Abstract**
The average rainfall for the El Nino years (strong and moderate El Nino) calculated and compared with the normal rainfall for the years 1981 to 2016 during the four different seasons and also computed for the seasons in different districts. Present study data revealed that the average rainfall during the S-W monsoon season during the El Nino years was less than the normal rainfall in all the district of Eastern UP. The average annual rainfall or S-W monsoon season rainfall were less than normal rainfall during the years with El Nino. Production and productivity of Chickpea crop were decline during El-Nino years as compared to normal. Maximum decline in production of Chickpea (33.1%) was recorded in Bahraich district, Maximum production of Rice crops were decline during (9.7%) in Varanasi district, Maximum decline in production of wheat (4.5%) was recorded in Bahraich district and Maximum departure in production of maize (23.3%) in Mirzapur. Agricultural production and productivity of the region during the El Nino years, As the S-W monsoon rainfall and annual rainfall are likely to less than normal in the region Duhan *at al.* (2017).. Short duration crops and varieties as main crops/intercropping system can be adopted in the region. Productivity of rabi crops can be improved by judicious use of fertilizers and adoption of insect pest & diseases control during the early stages of its growth. Plantation crops like fruit and timber plants are likely to yield decline due to decrease of pre- monsoon rainfall and therefore moisture conservation practices need to be adopted.

**Keywords:** El-Nino effect, normal rainfall, erratic monsoon, production, Productivity and intercropping.

## Introduction
The farmers are depended on the monsoon winds which are unpredictable. Increase in rainfall means a bumper crop production and erratic monsoon means a bad production of crops resulting into the loss of country's economy. So, in India still farmers depends upon the monsoon neglecting the technology and advancement in the field of agriculture. El-Nino refers to a large-scale ocean-atmosphere climate interaction associated with the episodic warming in sea surface temperatures (SST) across the central and east-central Equatorial Pacific. La Nina is an opposite event of El Nino which is termed as the episodic cooling of ocean SST in the central and east-central equatorial pacific, Bhuvaneswari, *et al.* (2013. El Niño events are mostly associated with warm and dry conditions in southern and eastern inland areas of Australia, as well as Indonesia, Philippines, Malaysia and central Pacific islands such as Fiji, Tonga and Papua New Guinea. The inter-annual variability of Indian summer monsoon rainfall (ISMR) has been linked to variations of Sea Surface Temperatures (SST) over the equatorial Pacific and Indian Oceans. ENSO events have a profound impact on summer monsoonal rainfall across India and most of the major droughts have occurred during El Nino events. However, its reverse is not always true. Previously El Niño had a strong association with droughts in India but this relationship has been weekend in recent years. El Niño conditions mostly coincide with a period of weak monsoon and rising temperatures in India and thus the probability of drought occurrence surges during El Nino events that could be disturbing for Indian crop production and water supply, Deng *et al.* (2010). Rainfall is the direct source for both rainfed and irrigated agriculture. In general, It drives the agricultural productivity of India. The quantum and the distribution of rainfall determine the agricultural productivity. In Eastern U.P., It determines not only the crop selections during kharif season but also the crop sequences in double cropping system in rabi season. Thus the monsoonal rainfall and its distribution are very crucial for crop success in Eastern Uttar Pradesh. The term El Nino and La Nina both have their origin in Spanish language with their respective meanings are “Christ child” and “a little girl” respectively. The name El Nino was chosen since as El-Nino events starts around December near Christmas, Devilal (2019). El-Nino refers to a large-scale ocean-atmosphere climate interaction associated with the episodic warming in sea

surface temperatures (SST) across the central and east-central Equatorial Pacific. Fishermen from the coast of South America recognized this event with the appearance of unusually warm water in the Pacific Ocean. La Nina is an opposite event of El Nino which is termed as the episodic cooling of ocean SST in the central and east-central equatorial pacific, Dhyani *et al.* (2002). The fluctuations in SST during El Nino and La Nina events are associated with large fluctuations in air pressure which is termed as Southern Oscillation.

## Methods and materials

### Rainfall data

### Crop data – District wise

The area, production and yield of food grains, pulses, and oilseeds in different districts of Eastern U.P. for the years 1981 to 2016 were obtained from Directorate of Economics and Statistics, Government of U.P. Average production of major crops was worked out for all the selected districts for the period. Average area, production & yield of the crops in the El Nino years was worked out and comparison was made with overall average normal value for the purpose of weak, moderate or strong the El Nino years were classified from 1951 to 2016 as follows:

| Intensity | Years |
|---|---|
| Weak | 1951, 1963, 1968, 1969, 1976, 1977, 2004, 2006 |
| Moderate | 1986, 1987, 1994, 2002 |
| Strong | 1957, 1965, 1972, 1982, 1991, 1997, 2009, 2014, 2015 |

During the period considered for the present study from 1981 to 2016, there were 10 moderate and strong and two weak El Nino events out of 36 years.

## Result and Discussion:

**Influence on Rainfall:** El Nino suggests the possibility of decline in production and productivity of total food grain in region. The effect of decreasing tendency of the SW monsoon rainfall on food grain production during El Nino years appears to be more in larger parts of the region;

**Rice:** Production and productivity of Rice crop of different districts were less during El-Nino years as compared to normal (Table -3). Maximum decline in production (9.7%) was recorded in Varanasi district followed by 7.2% in Basti and 7.2% Gonda district. However minimum production decline by 0.3% was recorded in Gorakhpur district. Maximum decline in productivity 7.1% was recorded in Varanasi district. followed by 5.7% decline in Azamgarh district. The minimum decline in productivity by 0.2% was recorded in Ghazipur district.

**Maize:** Production and productivity of Maize crop of different districts were less during El-Nino years as compared to normal (Table - 4). Maximum departure in production of maize (23.3%) over normal was found in Mirzapur district while minimum (1.2%) in Mau district followed by 1.7% decline over normal was in Ballia district. Data pertaining to yield, maximum decline due to El Nino over normal (12.8%) was found in Gagipur district followed by Sonbhadra district (9.6%) while minimum departure in yield of maize (0.3%) was found in Ballia district of Eastern U.P.

**Wheat:** Production and productivity of Wheat crop of different districts were less during El-Nino years as compared to normal (Table - 5). Maximum decline in production of wheat (4.5%) was recorded in Bahraich district while that of minimum decline was 0.7% in Deoria district. However, data pertaining to yield, maximum decline (2.5%) was recorded in Bahraich district followed by 2.4% decline in Siddharthnagar district of Eastern U.P. while minimum (0.2%) in Mirzapur and Ghazipur district.

**Chickpea:** Production and productivity of Chickpea crop of different districts were less during El-Nino years as compared to normal (Table - 6). Maximum decline in production of Chickpea (33.1%) was recorded in Bahraich district while that of minimum decline was (2.7%) in Azamgarh district. However, data pertaining to yield, maximum decline (31.8%) was recorded in Bahraich district followed by 9.4% decline in Barabanki district of Eastern U.P. while minimum (0.1%) in Ballia and Sonbhadra district.

**Table 1:** Per cent change in average seasonal rainfall (mm) during El Nino years as compared to normal rainfall (mm) in Eastern Uttar Pradesh (1981-2016).

| Name of Districts | Winter (Jan-Feb) | | | Summer (Mar-May) | | | SW Monsoon (Jun-Sept) | | | Post Monsoon (Oct-Dec) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | El Nino | Normal | PC | El Nino | Normal | PC | El Nino | Normal | PC | El Nino | Normal | PC |
| Jaunpur | 48 | 53.2 | -10.8 | 78 | 84.2 | -7.9 | 882 | 886.2 | -0.4 | 70 | 72 | -2.8 |
| Ghazipur | 40 | 47 | -17.5 | 62 | 74.5 | -20.1 | 910 | 929.8 | -2.1 | 45 | 66.5 | -47.7 |
| Ballia | 42 | 46.3 | -10.2 | 70 | 70.2 | -0.2 | 913 | 892.2 | 2.3 | 58 | 67.4 | -13.9 |
| Maharajganj | 51 | 52 | -1.9 | 130 | 140 | -7.6 | 962 | 970 | -0.8 | 100 | 112 | -10.7 |
| Gorakhpur | 55 | 57 | -3.6 | 187 | 155.9 | 16.6 | 1005 | 982.1 | 2.3 | 109 | 122.2 | -10.8 |
| Deoria | 65 | 61.5 | 5.3 | 120 | 130 | -8.3 | 1003 | 988.7 | 1.4 | 99 | 103 | -4.0 |
| Basti | 91 | 97.9 | -7.5 | 143 | 152.8 | -6.4 | 1010 | 1027.7 | -1.7 | 111.5 | 121.5 | -8.2 |
| Siddharthnagar | 89 | 97.1 | -8.3 | 147 | 152.8 | -3.8 | 1021 | 1041.2 | -1.9 | 104 | 119.5 | -13.0 |
| Azamgarh | 47 | 51.8 | -9.3 | 76 | 78.1 | -2.7 | 873 | 899.7 | -3.0 | 75 | 73 | 2.6 |
| Mau | 44 | 42 | 4.5 | 74 | 80 | -7.5 | 890 | 900 | -1.0 | 60 | 65 | -7.7 |
| Faizabad | 72 | 79.8 | -9.8 | 102 | 103.5 | -1.4 | 866 | 891.3 | -2.9 | 90 | 86.8 | 3.7 |
| Gonda | 76 | 82.7 | -8.1 | 140 | 136.6 | 2.5 | 1002 | 1011.8 | -1.0 | 120 | 117.6 | 2 |
| Bahraich | 61 | 67.5 | -10.6 | 100 | 103.8 | -3.7 | 947 | 994.5 | -4.8 | 90 | 88.7 | 1.5 |
| Sultanpur | 63 | 66.7 | -5.5 | 93 | 100.2 | -7.7 | 825 | 886 | -7.3 | 75 | 72.5 | 3.4 |
| Barabanki | 58 | 64 | -9.4 | 81 | 88.4 | -8.4 | 800 | 878.7 | -9.0 | 68 | 74.8 | -9.1 |
| Varanasi | 80 | 87.7 | -9.6 | 67 | 72.7 | -7.8 | 876 | 926.7 | -5.5 | 58 | 67.2 | -15.8 |
| Mirzapur | 380 | 400 | -5.0 | 88 | 86.6 | 1.5 | 900 | 935 | -3.8 | 62 | 68.8 | -9.9 |
| Sonbhadra | 130 | 140 | -7.6 | 87 | 90 | -3.3 | 842 | 876 | -3.9 | 60.5 | 65 | -7.4 |

**Table 2:** Per cent change in district wise average annual rainfall (mm) during El Nino years as compared to normal rainfall years in Eastern Uttar Pradesh (1981 to 2016).

| Name of Districts | Rainfall ( mm ) | | |
|---|---|---|---|
| | El Nino years | Normal years | Percentage change |
| Jaunpur | 937 | 985 | -5.1 |
| Ghazipur | 1000 | 1034 | -3.4 |
| Ballia | 927 | 980 | -5.7 |
| Maharajganj | 1280 | 1350 | -5.4 |
| Gorakhpur | 1177 | 1225 | -4.0 |
| Deoria | 1162 | 1203 | -3.5 |
| Basti | 1146 | 1169 | -2.0 |
| Siddharthnagar | 1292 | 1376 | -6.5 |
| Azamgarh | 1003 | 1030 | -2.6 |
| Mau | 1049 | 1070 | -2.0 |
| Faizabad | 985 | 1002 | -1.7 |
| Gonda | 1125 | 1152 | -2.4 |
| Bahraich | 1113 | 1128 | -1.3 |
| Sultanpur | 999 | 1005 | -0.6 |
| Barabanki | 1044 | 1059 | -1.4 |
| Varanasi | 1080 | 1079 | 0.0 |
| Mirzapur | 978 | 1022 | -4.4 |
| Sonbhadra | 999 | 1015 | -1.6 |

**Table 3:** Per cent change in District wise average area sown (ha), production (tons) and yield (kg $ha^{-1}$) of Rice during El Nino year compared to normal years of Eastern Uttar Pradesh (1981 to 2016).

| Name of Districts | Area | | | Production | | | Yield | | |
|---|---|---|---|---|---|---|---|---|---|
| | El Nino | Normal | PC* | El Nino | Normal | PC | El Nino | Normal | PC |
| Jaunpur | 152653 | 157279 | -3.0 | 348460 | 362683 | -4.0 | 2283 | 2306 | -1.0 |
| Ghazipur | 152547 | 154816 | -1.4 | 377651 | 384250 | -1.7 | 2475 | 2482 | -0.2 |
| Ballia | 113013 | 115680 | -2.3 | 280014 | 289551 | -3.4 | 2476 | 2504 | -1.1 |
| Maharajganj | 165047 | 166401 | -0.8 | 401647 | 413836 | -3.0 | 2433 | 2487 | -2.2 |
| Gorakhpur | 151653 | 153183 | -1.0 | 389748 | 390920 | -0.3 | 2568 | 2552 | 0.6 |
| Deoria | 134253 | 135888 | -1.2 | 301457 | 312408 | -3.6 | 2245 | 2298 | -2.3 |
| Basti | 103245 | 105369 | -2.0 | 291487 | 312627 | -7.2 | 2822 | 2967 | -5.1 |
| Siddharthnagar | 171521 | 173506 | -1.1 | 421545 | 449210 | -6.5 | 2457 | 2588 | -5.3 |
| Azamgarh | 214326 | 216040 | -0.7 | 481573 | 512234 | -6.3 | 2242 | 2371 | -5.7 |
| Mau | 90013 | 91322 | -1.4 | 204875 | 217894 | -6.3 | 2276 | 2386 | -4.8 |
| Faizabad | 99144 | 101926 | -28.0 | 254876 | 263888 | -3.5 | 2570 | 2588 | -0.7 |
| Gonda | 121324 | 125428 | -3.3 | 274551 | 294507 | -7.2 | 2263 | 2348 | -3.7 |
| Bahraich | 161844 | 164734 | -1.7 | 394587 | 418920 | -6.1 | 2438 | 2543 | -4.3 |
| Sultanpur | 94155 | 95968 | -1.9 | 295486 | 306621 | -3.7 | 3137 | 3196 | -1.8 |
| Barabanki | 175648 | 181604 | -3.3 | 497894 | 520658 | -4.5 | 2834 | 2867 | -1.1 |
| Varanasi | 50494 | 51718 | -2.4 | 120134 | 131831 | -9.7 | 2378 | 2547 | -7.1 |
| Mirzapur | 83324 | 84711 | -1.6 | 212457 | 215755 | -1.5 | 2548 | 2547 | 0.0 |
| Sonbhadra | 37974 | 38873 | -2.3 | 102488 | 105697 | -3.1 | 2699 | 2718 | -0.7 |

* PC indicates per cent change

**Table 4:** Per cent change in District wise average area sown (ha), production (tons) and yield (kg $ha^{-1}$) of Maize during El Nino year compared to normal years of Eastern Uttar Pradesh (1981 to 2016).

| Name of Districts | Area | | | Production | | | Yield | | |
|---|---|---|---|---|---|---|---|---|---|
| | El Nino | Normal | PC* | El Nino | Normal | PC | El Nino | Normal | PC |
| Jaunpur | 42345 | 43085 | -1.7 | 64728 | 66654 | -2.9 | 1527 | 1546 | -1.2 |
| Ghazipur | 615 | 628 | -2.1 | 540 | 622 | -15.1 | 878 | 991 | -12.8 |
| Ballia | 27896 | 28303 | -1.4 | 52863 | 53776 | -1.7 | 1894 | 1900 | -0.3 |
| Maharajganj | 43 | 42 | 2.3 | 83 | 83 | 0.0 | 1930 | 1927 | 0.1 |
| Gorakhpur | 2355 | 2459 | -4.4 | 1046 | 1124 | -7.4 | 443 | 457 | -3.1 |
| Deoria | 5118 | 5278 | -3.1 | 10745 | 11272 | -4.9 | 2098 | 2133 | -1.6 |
| Basti | 2455 | 2550 | -3.8 | 2157 | 2249 | -4.2 | 878 | 882 | -0.4 |
| Siddharthnagar | 408 | 415 | -1.7 | 355 | 366 | -3.0 | 870 | 882 | -1.3 |
| Azamgarh | 5364 | 5554 | -3.5 | 8645 | 8998 | -4.0 | 1612 | 1620 | -0.4 |
| Mau | 291 | 298 | -2.4 | 545 | 552 | -1.2 | 1872 | 1853 | 1.0 |
| Faizabad | 1345 | 1463 | -8.7 | 2246 | 2468 | -9.8 | 1667 | 1687 | -1.1 |
| Gonda | 42864 | 45982 | -7.2 | 51487 | 55821 | -8.4 | 1201 | 1213 | -0.9 |
| Bahraich | 74975 | 77445 | -3.2 | 122482 | 133671 | -9.1 | 1632 | 1726 | -5.7 |
| Sultanpur | 4237 | 4395 | -3.7 | 7118 | 7414 | -4.1 | 1678 | 1686 | -0.4 |
| Barabanki | 3446 | 3546 | -2.9 | 5731 | 5984 | -4.4 | 1663 | 1686 | -1.3 |
| Varanasi | 2633 | 2898 | -10.0 | 4586 | 5142 | -12.1 | 1740 | 1773 | -1.8 |
| Mirzapur | 1042 | 1182 | -13.4 | 1437 | 1773 | -23.3 | 1380 | 1500 | -8.6 |
| Sonbhadra | 13096 | 13854 | -5.7 | 11148 | 12926 | -15.9 | 851 | 933 | -9.6 |

* PC indicates per cent change

**Table 5:** Per cent change in District wise average area sown (ha), production (tons) and yield (kg ha$^{-1}$) of Wheat during El Nino year compared to normal years of Eastern Uttar Pradesh (1981 to 2016).

| Name of Districts | Area | | | Production | | | Yield | | |
|---|---|---|---|---|---|---|---|---|---|
| | El Nino | Normal | PC* | El Nino | Normal | PC | El Nino | Normal | PC |
| Jaunpur | 204271 | 207668 | -1.6 | 711468 | 735146 | -3.3 | 3482 | 3542 | -1.7 |
| Ghazipur | 164510 | 166213 | -1.0 | 488249 | 494151 | -1.2 | 2967 | 2973 | -0.2 |
| Ballia | 134970 | 136892 | -1.4 | 483479 | 495067 | -2.3 | 3582 | 3616 | -0.9 |
| Maharajganj | 143214 | 145442 | -1.5 | 502984 | 515741 | -2.5 | 3512 | 3546 | -1.0 |
| Gorakhpur | 190113 | 192243 | -1.1 | 793491 | 814341 | -2.6 | 4173 | 4236 | -1.5 |
| Deoria | 151795 | 153401 | -1.0 | 478974 | 482139 | -0.7 | 3155 | 3143 | 0.4 |
| Basti | 116624 | 119616 | -2.5 | 462484 | 471766 | -2.0 | 3964 | 3944 | 0.5 |
| Siddharthnagar | 156348 | 158257 | -1.2 | 607508 | 629705 | -3.5 | 3885 | 3979 | -2.4 |
| Azamgarh | 231396 | 235095 | -1.5 | 784628 | 808724 | -3.0 | 3390 | 3440 | -1.5 |
| Mau | 93975 | 95373 | -1.5 | 340141 | 352975 | -3.6 | 3619 | 3701 | -2.2 |
| Faizabad | 105742 | 109263 | -3.2 | 398975 | 412905 | -3.4 | 3773 | 3779 | -0.2 |
| Gonda | 151356 | 154304 | -1.9 | 450525 | 463529 | -2.8 | 2976 | 3004 | -0.9 |
| Bahraich | 164214 | 167792 | -2.1 | 600794 | 629399 | -4.5 | 3658 | 3751 | -2.5 |
| Sultanpur | 112464 | 114555 | -1.8 | 450486 | 461653 | -2.4 | 4004 | 4031 | -0.6 |
| Barabanki | 165120 | 168346 | -1.9 | 655046 | 677088 | -3.3 | 3967 | 4022 | -1.4 |
| Varanasi | 68953 | 69363 | -0.6 | 231185 | 234527 | -1.4 | 3352 | 3381 | -0.9 |
| Mirzapur | 92589 | 94546 | -2.1 | 272475 | 278692 | -2.2 | 2942 | 2948 | -0.2 |
| Sonbhadra | 53581 | 54273 | -1.2 | 125234 | 127922 | -2.1 | 2337 | 2357 | -0.8 |

* PC indicates per cent change

**Table 6:** Per cent change in District wise average area sown (ha), production (tons) and yield (kg ha$^{-1}$) of Chickpea during El Nino year compared to normal years of Eastern Uttar Pradesh (1981 to 2016).

| Name of Districts | Area | | | Production | | | Yield | | |
|---|---|---|---|---|---|---|---|---|---|
| | El Nino | Normal | PC* | El Nino | Normal | PC | El Nino | Normal | PC |
| Jaunpur | 4987 | 5050 | -1.2 | 7124 | 7482 | -5.0 | 1426 | 1481 | -3.8 |
| Ghazipur | 4117 | 4262 | -3.5 | 7042 | 7385 | -4.8 | 1710 | 1730 | -1.1 |
| Ballia | 3145 | 3338 | -6.1 | 5261 | 5600 | -6.4 | 1672 | 1675 | -0.1 |
| Maharajganj | 4 | 3 | 25 | 4 | 3 | 25 | 1000 | 1060 | -6.0 |
| Gorakhpur | 348 | 351 | -0.8 | 376 | 373 | 0.8 | 1080 | 1065 | 1.4 |
| Deoria | 111 | 110 | 0.9 | 119 | 117 | 1.7 | 1070 | 1065 | 0.4 |
| Basti | 918 | 909 | 1.0 | 900 | 973 | -8.1 | 980 | 1071 | -8.5 |
| Siddharthnagar | 20 | 20 | 0.0 | 22 | 22 | 0.0 | 1047 | 1071 | -2.2 |
| Azamgarh | 3141 | 3223 | -2.5 | 3301 | 3391 | -2.7 | 1050 | 1055 | -0.4 |
| Mau | 1348 | 1426 | -5.5 | 1421 | 1500 | -5.3 | 1054 | 1052 | 0.2 |
| Faizabad | 1455 | 1558 | -7.0 | 1048 | 1173 | -11.9 | 719 | 754 | -4.6 |
| Gonda | 641 | 650 | -1.4 | 624 | 681 | -8.4 | 973 | 1048 | -7.2 |
| Bahraich | 305 | 306 | -0.3 | 241 | 321 | -33.1 | 790 | 1042 | -31.8 |
| Sultanpur | 1879 | 1966 | -4.6 | 1346 | 1483 | -9.2 | 716 | 754 | -5.0 |
| Barabanki | 746 | 779 | -4.2 | 510 | 585 | -14.7 | 683 | 754 | -9.4 |
| Varanasi | 1856 | 1926 | -3.6 | 2697 | 2876 | -6.2 | 1453 | 1490 | -2.5 |
| Mirzapur | 12983 | 13805 | -6.3 | 17977 | 19558 | -8.1 | 1384 | 1417 | -2.3 |
| Sonbhadra | 10452 | 11298 | -7.5 | 14402 | 15574 | -7.5 | 1377 | 1378 | -0.1 |

## Summary and Conclusion

The inter-seasonal and intra-seasonal variability in weather is believed in recent years to outsmart the abilities of climatologist. Analysis of long term data suggests an inverse relationship between El Nino and SW monsoon rainfall. Agricultural production and productivity of the region during the El Nino years; As the S-W monsoon rainfall and annual rainfall are likely to less than normal in the region. Short duration crops and varieties as main crops/intercropping system can be adopted in the region. Productivity of rabi crops can be improved by judicious use of fertilizers and adoption of insect pest & diseases control during the early stages of its growth. In those districts where ever rice yields are likely to decline, rice may be cultivated under System of Rice Intensification (SRI) method during kharif season. Plantation crops like fruit and timber plants are likely to yield decline due to decrease of pre- monsoon rainfall and therefore moisture conservation practices need to be adopted. Vegetable production during summer season is likely to get affected and production can be sustained by promoting pre-urban olericulture and use of shade nets. As the data considered uptill now indicates greater vulnerability of crop production during years with strong and moderate El Nino events, formers have to be cautioned.

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