A rainstorm occurred in Shanxi province, northern China, on June 13, 2007 is simulated using the Weather Research and Forecasting (WRF) mesoscale model coupled with the Morrison’s double-moment bulk microphysical scheme. Sensitivity tests are conducted and compared for different background conditions to understand the response of cloud microphysical processes and precipitation to changes in concentrations of aerosol particles. The results show that the total rainfall amount is reduced by about 7.3% in the polluted case as compared with the clean case, but a more intensive rainfall rate at the central region of the rained area and a smaller rainfall area are observed in the former case than in the latter. It is also found that in the polluted case, while the area of moderate rain becomes smaller, the spread of light and heavy rain becomes larger. Torrential rain also occurs in the polluted case but is absent in the clean case. Graupel and snow crystals are the main sources for rain at the surface, and graupel is mainly formed by coagulations between cloud droplets and snow crystals. In the polluted case considered here, higher concentration of aerosol particles leads to smaller size of ice particles, and consequently more numerous particles can be suspended in the air for longer, delaying precipitation formation at the early stage and intensifying that at the later stage.