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Special values of certain Gaussian hypergeometric functions have interesting relationships to numbers of \mathbb{F}_p -points on algebraic varieties, and to the Fourier coefficients of certain Hecke eigenforms. Several recent works, including the authors' collaborations with Ono, and work of Ahlgren and Ono, have explored these connections. Continuing along these lines, we investigate certain one parameter families of n -dimensional varieties over \mathbb{F}_p , defined using hypergeometric weight systems given by Rodriguez-Villegas. We show that the numbers of \mathbb{F}_p -points on these varieties can be expressed in terms of sums of special values of ${}_k F_k$ Gaussian hypergeometric functions, for $1 \leq k \leq n$. Moreover, we discuss the potential connections between special values of ${}_4 F_3$ Gaussian hypergeometric functions and the Fourier coefficients of Siegel modular forms. (Received September 28, 2005)