$$PFP = \frac{Y_o}{N_r} + AE \qquad (2)$$

where: AE : the incremental efficiency or Agricultural Efficiency from purchase N input

PFP: Partial Factor Productivity

ΔY : the incremental increase in grain yield that results from N application.

Y_o : grain yield without N input

N_r : nitrogen rate applied

Calculation used in this research were RMSE (Root Mean Square Error), RMSEn (Normalized Root Mean Square Error), SD (Standard Deviation), R^2 (R square), and D-index or d-Statistics (index of agreement).

The RMSE was used to compare the difference between observed data from field experiment and simulated data from crop simulation model. The model reproduced experimental data perfectly when RMSE value was 0 using the following formula:

$$RMSE = \left[N^{-1} \sum_{i=1}^{n} (p_i - o_i)^2 \right]^{0.5} \qquad (3)$$

where: p_i: simulated value

o_i: observed value

N: number of observation (equal to number of simulation)

(Wallach and Goffinet, 1987; Timsina and Humphreys, 2006)

The RMSEn was computed for each parameter to compare the outputs from simulation against observation data using the following equation;

$$RMSEn = \frac{RMSE \times 100}{\overline{o}} \quad (4)$$

where: $\overline{o}$: the overall mean of observation values

(Loague and Green, 1993)

The D-index or d-statistic was a descriptive (both relative and bounded) measure, it was applied to calculate the agreement between observed values and simulated values. It ranged between zero to one, with one being the best fit (Timsina and Humphreys, 2006; Anothai, *et al*., 2008). The formula to calculate the D-index was shown below:

$$D - index = 1 - \left[\sum_{i-1}^{n} (p_i - o_i)^2 / \sum_{i-1}^{n} (|p_i'| + |o_i'|)^2 \right] \quad (5)$$

where: p_i': $p_i - \overline{o}$

o_i': $o_i - \overline{o}$

R^2 value ran from 0 (proposed model does not fit at all) to 1 (proposed model fits the data perfectly). The calculation was as follows:

$$R^2 = 1 - \frac{\sum_i (y_i - y_i^e)^2}{\sum_i (y_i - \overline{y})^2} \quad (6)$$

$$\overline{Y} = \frac{1}{n}\sum_{i=1}^{n} y_i \qquad (7)$$

where: y_i: observed i[th] of parameter *y*

y_i^s: simulated i[th] of parameter *y*

$\overline{y}$: arithmetic mean of parameter *y*

n : number of parameter *y*

(Kammen and Hassenzahl, 2001)