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# Influence of nitrogen and potash fertilizer on yield and quality of papaya cv. red lady under alluvial soil of Bihar

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## Abstract
Papaya (*Carica papaya* L.) cv. Red Lady, a high-yielding gynodioecious tropical fruit of the *Caricaceae* family, was studied to evaluate the effects of various fertilizer doses on its yield and quality attributes. Neem-coated urea (0, 100, 200 g/plant), calcium nitrate (0, 100, 200 g/plant), and muriate of potash (0, 200, 400 g/plant) were applied in different combinations. The results showed significant variation in yield parameters, with the number of flowers ranging from 16.125 to 23.125, fruits per plant from 11.50 to 20.50, and fruit yield per plant from 10.649 to 18.412 kg. Quality attributes such as total soluble solids (TSS), acidity, and carotenoid content of ripe fruits varied from 7.150 to 9.600 °Brix, 0.305 to 0.350%, and 1.637 to 3.795 mg/100 g fresh weight, respectively. Fruit firmness ranged between 7.500 and 10.500 kg/cm², while fruit volume was recorded between 820.00 and 973.750 ml. This study highlights the influence of balanced fertilizer management on optimizing yield and improving fruit quality in papaya cultivation.

**Keywords:** Papaya (*Carica papaya* L.), red lady cultivar, gynodioecious, tropical fruit

## Introduction
Papaya (*Carica papaya* L.) is an important tropical fruit of *Caricaceae* family. There are 48 species under genus *Carica* in which only *Carica papaya* is grown for consumption. It is a nutrient loving plant that requires relatively more nutrient during entire growing period. Proper nutrient management is necessary for optimum yield with quality fruit (Purohit, 1984) [24]. For the growth of different tissues/organ, it needs varying amounts of different nutrients throughout the growing period. The higher or lower doses of fertilizer may cause adverse effects on plant growth and development. Nitrogen, directly related to fruit production (Koo, 1957) [10]. Nitrogen contributes mainly in proteins, nucleic acid and chlorophyll, besides its direct role in cell division and expansion (Marchner, 2005) [17]. Its management is very complex due to leaching losses, different soil biochemical reaction and dependency on climatic parameters (Hu *et al*., 2012) [16]. Potassium, as a quality nutrient, increases the fruit quality of papaya *viz*. pulp thickness, fruit size, high TSS with low acidity content (Römheld and Kirby, 2010) [22]. It involves in different plant activities like a messenger to transfer electric charge with in cell system of plants and act as catalysts for an enzyme during several plant physiological activity. Due to activation of more than sixty enzyme in the plant system, potassium is recognize as 'spark plug'. Apart from all these activity, it stimulate tolerance mechanism in plant against biotic and abiotic stress (Ranade-Malvi, 2011) [21]. Therefore, N along with K is responsible for quality improvements of papaya fruits with high yield potential and other activity in plant system. Nitrogen and potassium exert strong correlation in plant growth and development. The optimum concentration of potassium in soil helps efficient utilization of nitrogen from the given source of nutrient or soil. Higher dose of nitrogenous fertilizers may cause nutritional imbalance in the plants and pollute the water table along with surroundings. The management practices of fertilization also becomes uneconomic, due to higher percentage of soluble forms of N in the soil profile, which may increase the susceptibility of the plants to losses (Lorenzini *et al*., 2012) [15] while, uptake of magnesium and calcium decreased at higher doses of potassium. Therefore, balance dose of fertilizer is important for plant growth.

## Materials and Methods

This trail was conducted at Horticulture Garden, Bihar Agricultural University, Sabour, Bhagalpur (Bihar) during the year 2017 and 2018. The trail consist of twenty seven treatment with three replication under factorial Randomised Block Design (FRBD). Uniform basal doses of phosphorus @ 100g per plant were given. Treatment consist with three levels of each neem coated urea, calcium nitrate (0g, 100g & 200g/plant) and muriate of potash (0, 200 & 400g/plant). Fertilizer applied in 4 equal splits (July, September, February and March), and placed 15-20 cm away from the plant in ring basin. The yield and yield attributing parameters of papaya cv. Red Lady were evaluated and statistically analysed.

The data were imperilled to analysis of variance (ANOVA) in order to get significant effects of N and K doses by Tukey test.

## Results and Discussion

The absorption and translocation of photosynthates from source to sink increases under good soil nutrient management that results better growth and yield of plant. Photosynthetic activity of plant might be increased due to more number of leaves and is responsible for more accumulation of carbohydrates that accelerate the growth rate and ultimately increases the fruit yield of papaya. Higher fruit yield (t/ha) in papaya was recognised due to increased number of fruits per plant.

The recorded pooled value of total no. of flowers, fruits and fruit yield per plant of papaya cv. Red Lady under the influence of various fertilizer doses is given in table 1.

It would be evident from the table that total no. of flowers, fruits and fruit yield varies significantly among the applied fertilizer doses. Number of flowers per plant showed highest value (23.125) in $N_0C_2M_2$ & equal to $N_2C_1M_1$ and lowest value (16.125) in $N_0C_2M_0$.

The value of number of fruits and fruit yield varied from 11.50 - 20.50 per plant and 10.649- 18.412 kg per plant respectively.

Number of flowers, fruits per plant, and yield per plant were examined and the maximum no. of flowers and yields per plant recorded with the application of $N_0C_2M_2$ (neem coated urea 0g, $CaNO_3$ @ 200 g along with MOP @ 400 g/plants) which is equal to $N_2C_1M_1$ (neem coated urea 200g, $CaNO_3$ @ 100 g along with MOP @ 200 g/plants). Number of fruits/plant increased continuously with increasing dose of nitrogen, while it increases only up to 200 g/plant dose of MOP application. This might be due to cumulative stimulating influence of nitrogen on vegetative plant parts that is the base for flowering and fruiting. The higher dose of Ca was more effective in enhancing average tuber weight in potato (Hamdi *et al*., 2015) [9]. However, El-Beltagy *et al*. (2002) [7], observed highest tuber yield with the application of medium doses of calcium nitrate. Rai *et al*. 2002 [20] observed that the fruit yield of litchi increased significantly with the application of potassium. Application of chemical fertilizer significantly enhances the fruit yield by increasing the soil fertility (Luo *et al*., 2012 and Zhao *et al*., 2013) [16, 30]. Similarly, Singh *et al*. 2012 recorded maximum number of fruit and fruit yields in papaya cv. Pusa Dwarf under application of nitrogen @ 200 g and potash @ 300 g/plant. Further, it was also recorded that application of organic matter @ 2250 kg/ha along with nitrogen @ 450 kg, phosphorus @ 247.5 kg and potassium @ 438 kg effectively improved the fruit yield of citrus cv. Longanyou (Li *et al*. 2017) [14]. Similar to this, Nasreen *et al*. (2013) [18], found that highest yield and yield components with the treatment of $N_{300}P_{125}K_{225}Mg_{60}$ g/plant in mandarin. Likewise, Young and Koo, 1974 [27] seen that increasing levels of nitrogen and potash increases the fruit yield in mango cv. Kent and Parvin but the effect is non-significant. In sweet pepper Aminifard *et al*. (2012) [2] and Law and Egharevba (2009) [13], observed that higher quantity of nitrogen enhances the fruit number and yield/plant but yield was decreased at highest dose of nitrogen. Fertilizer toxicity in soil may be one of the reason for reduction yield potential of plant (Boroujerdnia and Ansari, 2007) [5]. Number of primary and secondary fingers and rhizome fresh weight in ginger crop increases with the application of ideal levels of nitrogen in the soil (Singh *et al*., 2016; Xu and Xu, 1999) [27, 31].

**Table 1:** Effects of neem coated urea, calcium nitrate and muriate of potash on number of flowers, fruits and fruit yields per plant

| Treatment | No. of flowers/plant | No. of fruits/plant | Fruit yield (kg/plant) |
|---|---|---|---|
| $N_0C_0M_0$ | 16.125±0.854 | 11.50±1.940 | 10.649±0.901 |
| $N_0C_0M_1$ | 19.125±1.031 | 14.50±0.816 | 14.917±0.948 |
| $N_0C_0M_2$ | 21.125±0.854 | 14.75±1.940 | 14.749±1.058 |
| $N_0C_1M_0$ | 18.125±0.854 | 15.50 ±3.271 | 16.869±1.156 |
| $N_0C_1M_1$ | 19.125±1.031 | 16.50±1.505 | 18.412±0.853 |
| $N_0C_1M_2$ | 20.875±0.750 | 14.50 ±1.048 | 17.980±1.280 |
| $N_0C_2M_0$ | 21.125±0.854 | 14.50±1.048 | 16.293±1.383 |
| $N_0C_2M_1$ | 21.125±0.854 | 15.50±1.032 | 22.859±2.247 |
| $N_0C_2M_2$ | 23.125±0.854 | 14.50±1.632 | 19.882±2.591 |
| $N_1C_0M_0$ | 18.625±0.750 | 17.75±1.471 | 15.878±1.060 |
| $N_1C_0M_1$ | 19.125±1.030 | 18.50±2.898 | 17.013±1.385 |
| $N_1C_0M_2$ | 20.125±0.854 | 17.75±1.940 | 16.160±2.488 |
| $N_1C_1M_0$ | 19.125±0.854 | 15.50±1.505 | 15.605±2.092 |
| $N_1C_1M_1$ | 20.125 ±0.854 | 17.50±1.471 | 17.656±1.102 |
| $N_1C_1M_2$ | 19.125±1.031 | 18.50±1.414 | 17.920±1.627 |
| $N_1C_2M_0$ | 20.125±1.031 | 15.50±2.503 | 17.628±1.226 |
| $N_1C_2M_1$ | 20.625±0.854 | 20.50±1.940 | 18.442±2.166 |
| $N_1C_2M_2$ | 20.125±0.854 | 18.50±1.211 | 19.490±1.445 |
| $N_2C_0M_0$ | 21.150±0.854 | 15.50±2.316 | 14.370±1.482 |
| $N_2C_0M_1$ | 22.375±0.750 | 18.50±1.643 | 15.888±1.904 |
| $N_2C_0M_2$ | 19.250±0.645 | 17.75±1.048 | 14.898±1.610 |
| $N_2C_1M_0$ | 21.750±0.645 | 17.50±1.788 | 17.233±3.605 |
| $N_2C_1M_1$ | 23.125 ±0.854 | 18.50±1.632 | 19.959±1.282 |
| $N_2C_1M_2$ | 21.125± 0.854 | 19.25±0.752 | 17.757±0.783 |
| $N_2C_2M_0$ | 20.375±0.750 | 17.50±1.366 | 17.057±1.663 |
| $N_2C_2M_1$ | 21.875±0.854 | 19.50±0.547 | 17.522±1.299 |
| $N_2C_2M_2$ | 21.375 ±0.854 | 18.50±1.329 | 18.147±0.707 |
| CD | 1.214 | 1.44 | 2.30 |

Volume and fruit firmness of papaya fruit under the influence of various fertilizer doses were recorded at ripening stage and presented in table 2. Volume of papaya fruit varies from 820.00 - 973.750 ml among the applied fertilizer combination. The highest value of fruit volume 973.75±17.97 were recorded in $N_0C_2M_1$ followed by 968.75±42.89 $N_0C_2M_2$ and lowest value (820.00±9.128) in $N_0C_0M_0$. The fruit volume significantly affected by the application of potash and nitrogenous fertilizers and increased with decreasing dose of potash in combination with calcium nitrate @ 200g/plant and 0g urea. This finding is in line with Quaggio *et al*. (2006) [19], in sweet orange and Rai *et al*., 2002 [20] in litchi. However, Aminifard *et al*. (2012) [2], found that higher dose of nitrogen increases the fruit volume in sweet pepper.

Fruit firmness is determined by the fruit structure and cell wall composition, an important parameters to judge the fruit stability. Structural integrity cell wall and plasma membrane mainly determined by calcium. Suppression of ripening, senescence, less tissue break down and softening of tissue due to availability of sufficient quantity of secondary nutrient, metabolites such as gibberellic acid and lower gaseous exchange results in increasing the firmness of fruit (Parmar *et al*. 2017) [23], In present trial, fruit firmness of firm ripe fruit recorded highest (10.50 ±0.577 kg/cm$^2$) in $N_2C_1M_0$ which is at par with (10.375±0.478 kg/cm$^2$) $N_1C_0M_2$ followed by (10.125±0.629 kg/cm$^2$) in $N_1C_1M_2$ and lowest (7.50±0.408 kg/cm$^2$) in $N_0C_0M_0$. It was observed that firmness increased with combination of all higher doses of nitrogen followed by potash. These findings are in conformity with Parmar *et al*. (2017) [23] and Singh and Singh, (2010) [4].

**Table 2:** Effects of neem coated urea, calcium nitrate and muriate of potash on Fruit firmness and volume of papaya fruit

| Treatment | Fruit firmness (kg/cm$^2$) | Fruit volume (ml) |
|---|---|---|
| $N_0C_0M_0$ | 7.500±0.408 | 820.000±9.128 |
| $N_0C_0M_1$ | 8.125±0.250 | 915.000±25.166 |
| $N_0C_0M_2$ | 8.625±0.478 | 900.000±23.452 |
| $N_0C_1M_0$ | 9.000±0.000 | 868.750±28.686 |
| $N_0C_1M_1$ | 9.625±0.478 | 912.500±17.078 |
| $N_0C_1M_2$ | 9.625±0.250 | 930.000±26.140 |
| $N_0C_2M_0$ | 8.375±0.478 | 945.000±10.801 |
| $N_0C_2M_1$ | 8.500±0.408 | 973.750±17.969 |
| $N_0C_2M_2$ | 9.000±0.408 | 968.750±42.890 |
| $N_1C_0M_0$ | 8.250±0.645 | 930.000±19.578 |
| $N_1C_0M_1$ | 9.125±0.250 | 926.250±19.311 |
| $N_1C_0M_2$ | 10.375±0.478 | 927.500±16.583 |
| $N_1C_1M_0$ | 9.125±0.250 | 861.250±30.923 |
| $N_1C_1M_1$ | 9.375±1.108 | 903.750±28.686 |
| $N_1C_1M_2$ | 10.125±0.629 | 843.750±25.617 |
| $N_1C_2M_0$ | 9.375±0.478 | 922.500±27.838 |
| $N_1C_2M_1$ | 9.000±0.000 | 866.250±37.941 |
| $N_1C_2M_2$ | 9.625±0.478 | 908.750±23.935 |
| $N_2C_0M_0$ | 8.500±0.408 | 866.250±42.303 |
| $N_2C_0M_1$ | 9.375±0.478 | 880.000±9.128 |
| $N_2C_0M_2$ | 9.250±0.288 | 880.000±26.770 |
| $N_2C_1M_0$ | 10.50±0.577 | 868.750±57.209 |
| $N_2C_1M_1$ | 9.625±0.478 | 875.000±10.801 |
| $N_2C_1M_2$ | 9.875±0.629 | 891.750±10.275 |
| $N_2C_2M_0$ | 8.625±0.250 | 851.250±59.213 |
| $N_2C_2M_1$ | 9.000±0.408 | 801.250±12.500 |
| $N_2C_2M_2$ | 9.625±0.478 | 898.750±37.052 |
| CD | 0.6567 | 40.20 |

The different climatic factors *viz*. light, temperature, water, nutrient, soil and $CO_2$ governed the fruit quality by influencing growth rate and sugar content in leaves and fruits, productivity and development of fruit (Costa and Costa, 2003) [6].

Total Soluble Solids (TSS) and titratable acidity of papaya fruit were examined during 2017 and 2018 and pooled data has been presented in table 3. Combination of neem coated urea, calcium nitrate and muriate of potash to each other showed significant effect on TSS content of fruit. About 1.3 fold variation in pooled data was observed among the different combinations of fertilizer application. The highest value (9.60 ±0.141°Brix) was recorded under the interaction of $N_1C_1M_2$ which is at par with $N_2C_0M_2$ (9.55±0.212°Brix) followed by $N_0C_0M_2$ (9.35±0.07) and lowest in control $N_0C_0M_0$ (7.20±0.00) of ripe fruit. From this it has been observed that maximum TSS content recorded at higher doses of MOP i.e., @ 400 g/plant with the alone and in combination of other nitrogenous fertilizer @ 100 g/plant each.

Acidity of fruit with the combination of different fertilizers as neem coated urea, calcium nitrate and muriate of potash to each other showed the significant results. The lowest pooled value under the interaction of neem coated urea and calcium nitrate recorded as 0.305% when plant applied with $N_1C_2M_2$ and highest in control ($N_0C_0M_0$) i.e., 0.35%. However, all other combination give almost similar results.

**Table 3:** Effects of neem coated urea, calcium nitrate and muriate of potash on TSS, Acidity and carotenoid content of papaya fruit

| Treatment | TSS ($^0$brix) | Acidity (%) | Carotenoid (mg/100g FW) |
|---|---|---|---|
| $N_0C_0M_0$ | 7.200±0.000 | 0.350±0.028 | 1.637±0.154 |
| $N_0C_0M_1$ | 9.200±0.141 | 0.335±0.007 | 2.487±0.037 |
| $N_0C_0M_2$ | 9.350±0.070 | 0.345±0.007 | 2.485±0.019 |
| $N_0C_1M_0$ | 8.300±0.283 | 0.355±0.007 | 2.617±0.085 |
| $N_0C_1M_1$ | 8.100±0.000 | 0.345±0.007 | 2.510±0.154 |
| $N_0C_1M_2$ | 8.750±0.354 | 0.340±0.000 | 3.795±0.026 |
| $N_0C_2M_0$ | 8.250±0.212 | 0.370±0.000 | 2.775±0.046 |
| $N_0C_2M_1$ | 8.550±0.070 | 0.325±0.007 | 3.135±0.452 |
| $N_0C_2M_2$ | 8.750±0.354 | 0.360±0.000 | 2.557±0.254 |
| $N_1C_0M_0$ | 7.250±0.354 | 0.370±0.000 | 1.930±0.058 |
| $N_1C_0M_1$ | 8.850±0.354 | 0.340±0.000 | 3.535±0.029 |
| $N_1C_0M_2$ | 8.200±0.141 | 0.345±0.007 | 1.873±0.059 |
| $N_1C_1M_0$ | 7.150±0.354 | 0.370±0.000 | 2.515±0.052 |
| $N_1C_1M_1$ | 8.850±0.212 | 0.340±0.000 | 1.870±0.059 |
| $N_1C_1M_2$ | 9.600±0.141 | 0.335± 0.007 | 1.855±0.021 |
| $N_1C_2M_0$ | 8.250±0.354 | 0.345± 0.007 | 2.720±0.041 |
| $N_1C_2M_1$ | 8.700±0.141 | 0.345±0.007 | 3.277±0.088 |
| $N_1C_2M_2$ | 8.950±0.212 | 0.305±0.007 | 2.397±0.117 |
| $N_2C_0M_0$ | 7.450±0.212 | 0.355± 0.007 | 1.685±0.044 |
| $N_2C_0M_1$ | 7.750±0.070 | 0.350±0.000 | 1.757±0.029 |
| $N_2C_0M_2$ | 9.550±0.212 | 0.33±0.007 | 2.70±0.154 |
| $N_2C_1M_0$ | 8.600±0.283 | 0.35± 0.000 | 2.332±0.055 |
| $N_2C_1M_1$ | 8.900±0.141 | 0.34±0.007 | 2.422±0.159 |
| $N_2C_1M_2$ | 8.400±0.141 | 0.330±0.000 | 2.570±0.122 |
| $N_2C_2M_0$ | 7.550±0.212 | 0.350±0.000 | 2.417±0.0741 |
| $N_2C_2M_1$ | 8.500±0.283 | 0.340±0.000 | 3.100±0.114 |
| $N_2C_2M_2$ | 9.150±0.071 | 0.330±0.000 | 1.655±0.010 |
| CD | 1.4113 | 0.0144 | 0.1797 |

Fertilizer application either alone or in combination exert significant effect on carotenoids content of fruit. It varies in between 1.637±0.154 to 3.79±0.026 mg/100g. The maximum concentration of carotenoid were recorded under $N_0C_1M_2$ (3.79±0.026 mg/100g) followed by $N_1C_0M_1$ (3.535±0.029 mg/100g) and lowest in $N_0C_0M_0$ (1.637±0.154 mg/100g). From, this results it can be clear that both the nitrogenous fertilizer exerts equal effect on carotenoid content of fruit. According to Marshner (2012), potassium promote the sugar translocation in plant that results in higher TSS content of fruits. This is in conformity with Kumar *et al*. (2010) [12] and Souza *et al*. (2009) [29]. Higher dose of nitrogen increased the acidity content of fruit while potash reduces its content. Similar results in papaya were recorded by Bisht *et al*. (2010) [4] and Ghanta *et al.* (1995) [8]. However, TSS was not influenced with different doses of nitrogen, while highest dose (500g/plant/year) of potash results highest TSS content in papaya fruits (Akinyemi and Akanda, 2008; Kumar and Gho, 2003) [1, 11]. Likewise, Bindu and Bindu (2017), recorded maximum carotenoid content in fruits with the application of NPK @ 200:300:500 g/plant and also found that nitrogen has no significant effect on fruit TSS content. Similarly, Li *et al*., 2017 [14] found that application of nitrogen 450 kg, phosphorus 247.5 kg, potassium 438 kg and organic matter 2250 kg per hectare effectively increases the fruit quality of citrus fruit cv. Longanyou. Likewise, Nasreen *et al*. (2013) [18], observed that in mandarin higher concentration of nitrogen and potash increases the TSS content of fruit. Rai *et al*. (2002) [20], also recorded that TSS content of litchi fruit significantly influenced but acidity content was not significantly influenced by the nitrogen application.

## Conclusion
In conclusion, the application of neem-coated urea, calcium nitrate, and muriate of potash significantly influenced the growth, fruiting, and quality parameters of papaya cv. Red Lady. Optimal fertilizer combinations enhanced the number of flowers and fruits per plant, fruit yield, volume, firmness, and quality attributes like TSS and carotenoid content while reducing acidity. The highest number of flowers (23.125) and fruits per plant, along with increased fruit yield (19.882 kg/plant), were recorded with the treatments $N_0C_2M_2$ ($CaNO_3$ @ 200 g + MOP @ 400 g) and $N_2C_1M_1$ (neem-coated urea @ 200 g + $CaNO_3$ @ 100 g + MOP @ 200 g). This highlights the role of balanced fertilizer applications in optimizing nutrient uptake, promoting vegetative and reproductive growth, and achieving better yields. Excessive nitrogen or potassium applications, however, reduced yield potential, likely due to nutrient toxicity. Fruit quality was also enhanced under specific treatments. The highest TSS (9.60 °Brix) was observed with $N_1C_1M_2$ (neem-coated urea @ 100 g + $CaNO_3$ @ 100 g + MOP @ 400 g), indicating the synergistic role of nitrogen and potash in sugar accumulation. Firmness and carotenoid content were positively influenced by calcium and potassium applications, emphasizing their role in improving fruit structural integrity and nutritional quality. Overall, the findings underscore the importance of fine-tuning fertilizer doses for achieving high yields and superior fruit quality in papaya, while preventing nutrient imbalances or soil toxicity. Future studies can further refine the dose-response relationships to maximize productivity under diverse agro-climatic conditions.

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