

Quantifying the Nitrogen Requirement of Castor Cultivars in Post Monsoon Season on Alfisols

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The experiment is aimed at quantifying the nitrogen requirement and identifying suitable hybrids and varieties of castor to be grown during post monsoon season on Alfisols in Telangana

Study Design: Split plot design.

Place and Duration of Study: Regional Agricultural Research Station, Professor Jayashankar Telangana State Agricultural University, Palem, Telangana state, India during post monsoon season of 2010-11 and 2011-12.

Methodology: The study consisted of four N levels (0, 40, 80 kg and 120 kg N ha⁻¹) in main plots and five cultivars (DCH-177, PCH-111, GCH-4, Haritha and 48-1) in sub plots. The growth parameters, yield attributes, seed yield, water use efficiency, economic returns, correlation and regression were studied.

Results: The pooled data indicated that significantly taller plants with more no. of branches plant⁻¹, longer and effective spikes thus seed yield of castor were observed due to application of 80 kg

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Nha⁻¹ and 120 kg Nha⁻¹. However, application of 120 kg N ha⁻¹ resulted in greater net returns (USD 1049 ha⁻¹) and also returns per rupee invested (1.66). The results further showed that the castor hybrids PCH-111 (1900 kg/ha) and DCH-177 (1809 kg/ha) produced similar yield, but, both significantly outyielded over other cultivars. The performance of hybrids was superior to the varieties. A highly significant positive correlation was observed for seed yield with no. of branches/plant, total and effective spike length.

Conclusion: The cultivation of castor hybrids either PCH-111 or DCH-177 under N supply of 120 kg N ha⁻¹ would help to realize higher yields, water use efficiency and income from post monsoon season castor on Alfisols.

Keywords: Castor; economics; hybrid; N level; post monsoon season castor; variety.

1. INTRODUCTION

Castor is one of the nine important oilseed crops grown in India, having diversified uses. It is considered as a unique crop due to the presence of an unusual mono unsaturated, 18-carbon fatty acid known as 'ricinoleic acid' (80-90%) in it's oil. Traditionally, the castor oil is non-edible and is being used in aircraft lubricants, hydraulic fluids and explosives [1], synthesis of soaps, linoleum, printer's ink, nylon, varnishes, enamels, paints and electrical insulations. Further, sulphonated castor oil is used for dyeing and finishing of fabrics and leather, preservation of leather and production of rilson-polyamide nylon-type fiber [2]. It also has utility in the production of hydraulic fluid, artificial leather, recinol and greases [3]. Furthermore, from the recent past, it is attracting the attention of policy makers, engineers and scientists for the production of biodiesel as an alternate energy source with a view to minimize the consumption of fossil fuel across the globe [4,5]. Castor is widely cultivated crop in 30 different countries, of which India, China, Brazil, Mozambique, Ethiopia and Thailand are the major ones accounting for about 90% of the worlds' production. During 2019-20, it is cultivated in an area of 0.938 million ha with maximum area in Gujarat (0.702 million ha), Rajasthan (0.154 million ha), Andhra Pradesh (0.033 million ha) and Telangana (0.027 million ha). India has exported castor oil worth of more than USD 600 million during 2020 [6], thus, the crop has high export potential. However, this oilseed plant is often grown on light textured marginal Alfisols [7] under rainfed conditions and neglected management [8] leading to low productivity (500-600 kg ha⁻¹). The castor

growers are unable to realise higher economic yields due to incidence of *Botryotinia* gray rot (*Botrytis ricini*) and drought during monsoon season. Hence, growing castor as an irrigated dry crop (ID) during post monsoon season is a new dimension. In the recent times, the area under castor in post monsoon season is increasing in view of rise in demand for castor seeds due to multiple uses and also it's remunerative nature as compared to monsoon season castor and other competitive post monsoon season crops like groundnut, maize, jowar etc [9].

Among many agronomic aspects, identification of suitable cultivars and N management are very important for realising higher yields and returns. Though many cultivars are cultivated, newly developed ones are different from that of traditional ones in terms of plant architecture, morphological characters, branching pattern and production efficiency and yield potential may differ in various edapho-climatic zones and conditions. Castor is a heavy nutrient feeder. It is highly responsive to applied nitrogen, thus, judicious N management holds a key for successful castor production. The nitrogen requirement of newly released castor hybrids and cultivars may vary substantially with agronomic management, soil and climate especially under irrigated conditions in post monsoon season. Lack of such valuable and basic information is the main constraint for promotion of castor during post monsoon season on light textured Alfisols. Therefore, this study was executed to quantify the N requirement of castor hybrids and varieties in post monsoon season on Alfisols.



Haritha variety of castor



PCH-111 hybrid of castor

2. MATERIALS AND METHODS

2.1 Characterization of Experimental Site

A field study was conducted during post monsoon season 2010-11 and 2011-12 at the Regional Agricultural Research Station (RARS), Professor Jayashankar Telangana State Agricultural University, Palem, Telangana state, India. The experimental soil was near neutral with a pH of 6.5, low in organic carbon (0.4%) and available N (234 kg ha⁻¹), high in available P (78.1 kg P₂O₅ ha⁻¹) and K (412.2 kg K₂O ha⁻¹).

2.2 Treatments, Agronomic Management and Statistical Design

The experiment was conducted with four N levels viz., 0 kg N (control), 40 kg, 80 kg and 120 kg N ha⁻¹ and five cultivars including three hybrids (DCH-177, PCH-111 and GCH-4) and two varieties (Haritha and 48-1) in a split plot design (SPD) with three replications. The seeds (5 kg ha⁻¹) were treated with carbendazim (3 g kg⁻¹) and sown at a row to row distance of 90 cm and plant to plant distance of 60 cm on 14-10-2010 and 10-10-2011, on a well pulverized soil. An amount of 40 kg P₂O₅ and 30 kg K₂O ha⁻¹ through single super phosphate (SSP: 16% P₂O₅) and muriate of potash (MOP: 60% K₂O ha⁻¹) were applied as basal. Further, nitrogen (N) dose was applied as per the treatment, with 50% N as basal and remaining 50% N in three equal split doses at 30, 60 and 90 DAS. The leaf hopper (*Empoasca flavescens*) and tobacco caterpillar (*Spodoptera litura*) were managed by spraying Acephate 75% SP (1.5 glit⁻¹) and Novoluron 10% EC (1 ml lit⁻¹).

An amount of 81.4 mm rainfall in 6 rainy days and 21.2 mm in 4 days was received during the crop growing season in 2010-11 and 2011-12, respectively as recorded from

Agrometeorological observatory at RARS, Palem.

A gross plot size of 7.2m x 6.0m (8 rows x 10 plants) and a net plot size of 5.4 m x 4.8m (6 rows x 8 plants) were maintained. The crop was kept weed-free by spraying a pre-emergence herbicide Pendimethalin (1.0 kg a.i ha⁻¹) followed by two times intercultivation and one hand weeding between the plants. Five healthy plants with uniform growth were tagged from the net plot of each treatment to record the growth and yield attributes as per the standard procedures. Regarding seed yield, different order spikes were harvested during November-February and subjected to threshing. Seed from three pickings was summed to arrive at final seed yield. The water use efficiency (WUE: kg ha⁻¹ mm⁻¹) was computed by dividing the castor seed yield with amount of water used (water applied + effective rainfall).

The gross returns were computed by multiplying the castor seed yield with prevailing market price. Further, the net returns were calculated by deducting the cost of cultivation from gross returns and the B:C ratio was computed by dividing the gross returns with cost of cultivation. The experimental data was analysed using split plot design (SPD) with the help of OPSTAT software. The significance among the various treatments was determined using the f-test and the least significant differences (p=0.05) [10].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The data furnished in Table 1 showed that the plant height and no. of nodes plant⁻¹ were not significantly affected by graded levels of nitrogen. The no. of branches is a crucial factor in achieving higher castor seed yield. Production of more no. of branches produce greater no. of

spikes and capsules per plant thus higher seed yield [11]. In this study, castor plants produced more no. of branches plant⁻¹ when they were nourished with the highest level of N i.e. 120 kg Nha⁻¹, but, it was at par with that of 80 and 40 kg Nha⁻¹ (Table 1). Earlier, positive effects of higher N application on increase in the no. of branches plant⁻¹ due to better vegetative growth and other physical and morphological characters were reported [12,13,14]. The control treatment which did not receive N fertilizer recorded significantly least no. of growth parameters. This was in tune with the findings of [15] who reported stunted growth due to the non-functioning of chloroplasts following no or inadequate supply of nitrogen.

Among cultivars tested, 48-1 produced significantly taller plants (68.7 cm) with more no. of nodes plant⁻¹ (14.0). However, the cultivars did not differ significantly in no. of branches plant⁻¹ (Table 1).

3.2 Yield Attributes

The results furnished in Table 1 indicated that yield attributes viz., total and effective spike length, total and effective no. of spikes plant⁻¹ and seed yield were significantly affected by N rates and cultivars.

Among nitrogen doses, the total and effective spike length went on increasing with the graded level of N from 0 to 80 kg Nha⁻¹ and decreased thereafter. However, 40, 80 and 120 kg Nha⁻¹ were at par and significantly superior to control treatment (no N). Further, 120 and 80 kg Nha⁻¹ being at par, produced significantly more no. of total and effective spikes than that of 40 kg Nha⁻¹.

Seed yield is the most important desirable character. The castor seed yield increased linearly with increase in N application. The highest seed yield (2157kg ha⁻¹) was registered when 120 kg N/ha was supplied. It was higher by 62.8% and 137% over 40 kg Nha⁻¹ (1325 kg ha⁻¹) and control (910 kg ha⁻¹), respectively. However, it was on par with that of 80 kg Nha⁻¹ (2085 kg ha⁻¹). The superior performance of 120 and 80 kg Nha⁻¹ was mainly due to production of better growth and yield traits. The study by [16] also observed a significant improvement in seed yield in tune with an increase in the nitrogen levels from 0 to 60 to 120 kg Nha⁻¹. The synchronous and adequate availability of N as per the castor crop needs, might have contributed to better growth and yield attributing characters which

eventually resulted in higher seed yield at a higher level of N [17].

The performance of hybrids was found better than the varieties. Among all the cultivars evaluated, PCH-111 (1900 kg ha⁻¹) and DCH-177 (1809 kg ha⁻¹) were at par, but, significantly superior to GCH-4 (1600 kg ha⁻¹) and Haritha (1491 kg ha⁻¹) and 48-1 (1294 kg ha⁻¹) in producing seed yield. The superior performance of PCH-111 hybrid was mainly owing to significantly longer and effective spike length and also more no. of total and effective spikes plant⁻¹.

WUE followed the similar trend of seed yield of castor. The relation between N applied and WUE was linear, which could be due to improved growth, biomass and yield parameters thus seed yield with the supply of adequate amount of N to post monsoon season castor. Similarly, higher WUE with PCH-111 (3.23 kg ha⁻¹ mm⁻¹) and DCH-177 (3.07 kg ha⁻¹ mm⁻¹) hybrids was mainly due to higher seed yield of castor (Table 1). The castor hybrids were found to be water use efficient than varieties due to their inherent capacity to produce higher seed yields and ability to accumulate higher biomass per unit area and water.

3.3 Effect of Interaction of N Levels and Cultivars on Seed Yield

It is evident from Table 2 that, the interaction between N levels and castor cultivars was found to be significant. At a given level of N, PCH-111 and DCH-177 performed better than GCH-4, Haritha and 48-1. For a given cultivar, the seed yield showed linear improvement from control to 120 kg N kg ha⁻¹, but, 120 and 80 kg N ha⁻¹ were at par and significantly superior to other low N levels. Such a positive interaction between graded levels of N and cultivars in castor was earlier reported by [18].

3.4 Economic Analysis

In the current investigation, highest gross returns (USD 1684 ha⁻¹), net returns (USD 1049 ha⁻¹) and benefit-cost ratio (1.66) were accrued when castor crop was supplied with highest level of N (120 kg ha⁻¹). Similarly, among all the cultivars tested, the hybrid PCH-111 fetched higher gross returns (USD 1490 ha⁻¹), net returns (USD 876 ha⁻¹) and benefit-cost ratio (1.41) as compared to all other hybrids and varieties (Table 1). Further, it was noticed that cultivation of hybrids was profitable than varieties in post monsoon season.

Table 1. Ancillary traits, seed yield and economics of castor hybrids and varieties under different N levels (Pooled data of post monsoon season 2010-11 and 2011-12)

| N levels (kg ha ⁻¹) | Plant height (cm) | No. of branches plant ⁻¹ | No. of nodes plant ⁻¹ | Total spike length (cm) | Eff. spike length (cm) | No. of spikes plant ⁻¹ | No. of effective spikesplant ⁻¹ | Seed yield (kg ha ⁻¹) | WUE (kg ha ⁻¹ mm ⁻¹) | Gross returns (USD ha ⁻¹) | Net returns (USD ha ⁻¹) | B:C ratio |
|---------------------------------|-------------------|-------------------------------------|----------------------------------|-------------------------|------------------------|-----------------------------------|--|-----------------------------------|---|---------------------------------------|-------------------------------------|-----------|
| 0 | 54.3 | 4.2 | 13.1 | 47.4 | 42.8 | 5.6 | 5.2 | 910 | 1.55 | 716 | 137 | 0.24 |
| 40 | 56.2 | 4.6 | 13.1 | 51.5 | 48.0 | 5.1 | 4.6 | 1325 | 2.25 | 1032 | 414 | 0.68 |
| 80 | 57.6 | 5.1 | 13.0 | 55.0 | 51.3 | 6.1 | 5.6 | 2085 | 3.54 | 1627 | 1005 | 1.62 |
| 120 | 56.8 | 5.2 | 13.1 | 49.8 | 47.1 | 6.1 | 5.6 | 2157 | 3.67 | 1684 | 1049 | 1.66 |
| SEm± | 1.3 | 0.2 | 0.3 | 1.6 | 1.3 | 0.2 | 0.2 | 34 | 0.04 | | | |
| CD (p=0.05) | NS | 0.8 | NS | 5.7 | 4.5 | 0.8 | 0.8 | 116 | 0.14 | | | |
| CV% | 6.5 | 5.6 | 12.7 | 8.8 | 7.6 | 11.1 | 13.0 | 5.7 | | | | |
| Cultivars | | | | | | | | | | | | |
| DCH-177 | 54.2 | 4.6 | 12.6 | 53.0 | 48.7 | 5.4 | 5.0 | 1809 | 3.07 | 1414 | 799 | 1.29 |
| PCH-111 | 54.4 | 4.9 | 13.2 | 57.3 | 53.0 | 6.2 | 5.8 | 1900 | 3.23 | 1490 | 876 | 1.41 |
| GCH-4 | 50.9 | 4.7 | 12.0 | 51.3 | 48.8 | 5.2 | 4.8 | 1600 | 2.72 | 1242 | 626 | 1.00 |
| Haritha | 53.0 | 5.1 | 13.7 | 46.2 | 42.9 | 6.2 | 5.6 | 1491 | 2.53 | 1167 | 555 | 0.90 |
| 48-1 | 68.7 | 4.5 | 14.0 | 46.8 | 43.3 | 5.5 | 5.0 | 1294 | 2.20 | 1011 | 400 | 0.65 |
| SEm± | 2.0 | 0.3 | 0.26 | 1.9 | 1.7 | 0.4 | 0.3 | 46 | 0.05 | | | |
| CD (p=0.05) | 5.6 | NS | 0.74 | 9.2 | 8.6 | 15.4 | 15.6 | 131 | 0.16 | | | |
| CV% | 8.5 | 4.8 | 14.2 | 5.5 | 4.8 | 1.0 | 1.0 | 6.9 | | | | |

Market price: USD 0.78 kg⁻¹ seed; Water applied: 550 mm; Effective rainfall: 38.45 mm; Total water used: 588.45 mm

Table 2. Effect of Interaction between N levels and genotypes on seed yield of castor (Pooled data of post monsoon season 2010-11 and 2011-12)

| N level (kg ha ⁻¹)/Cultivars | 0 | 40 | 80 | 120 | Mean |
|--|------|------|-------------|------|------|
| DCH-177 | 917 | 1450 | 2358 | 2512 | 1809 |
| PCH-111 | 1056 | 1562 | 2490 | 2493 | 1900 |
| GCH-4 | 922 | 1332 | 2030 | 2117 | 1600 |
| Haritha | 834 | 1208 | 1895 | 2028 | 1491 |
| 48-1 | 820 | 1072 | 1654 | 1632 | 1294 |
| Mean | 910 | 1325 | 2085 | 2157 | |
| | | SEm± | CD (p=0.05) | | |
| Cultivar at the same level of N | | 64 | 185 | | |
| N at the same level of cultivar | | 71 | 212 | | |

Table 3. Correlation analysis between seed yield and yield influencing traits of castor (Pooled data of post monsoon season 2010-11 and 2011-2)

| Traits | Plant height (cm) | No. of branches plant ⁻¹ | No. of nodes plant ⁻¹ | Total spike length (cm) | Eff. spike length (cm) | No. of spikes plant ⁻¹ | No. of effective spikes plant ⁻¹ | Seed yield (kg ha ⁻¹) |
|---|-------------------|-------------------------------------|----------------------------------|-------------------------|------------------------|-----------------------------------|---|-----------------------------------|
| Plant height (cm) | 1.000 | -0.159 | 0.675* | -0.274 | -0.285 | -0.042 | -0.090 | -0.127 |
| No. of branches plant ⁻¹ | | 1.000 | 0.063 | 0.276 | 0.379 | 0.709* | 0.656* | 0.822** |
| No. of nodes plant ⁻¹ | | | 1.000 | -0.445 | -0.496 | 0.408 | 0.322 | -0.246 |
| Total spike length (cm) | | | | 1.000 | 0.982** | 0.151 | 0.237 | 0.626* |
| Eff. spike length (cm) | | | | | 1.000 | 0.140 | 0.215 | 0.701* |
| No. of spikes plant ⁻¹ | | | | | | 1.000 | 0.988** | 0.514 |
| No. of effective spikes plant ⁻¹ | | | | | | | 1.000 | 0.530 |
| Seed yield (kg ha ⁻¹) | | | | | | | | 1.000 |

Note: n-2=9-2=7

0.5822 *= Significant at 5% levels of probability, 0.7498 **= Significant at 1% levels of probability

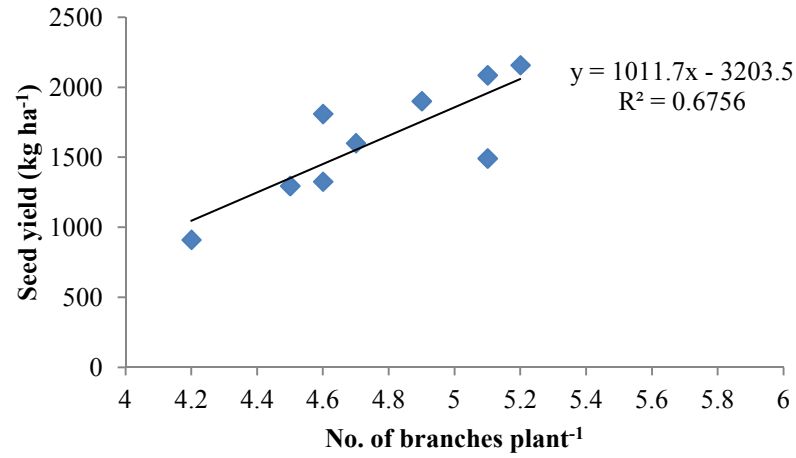


Fig. 1a. Relationship between branchesplant⁻¹ and seed yield

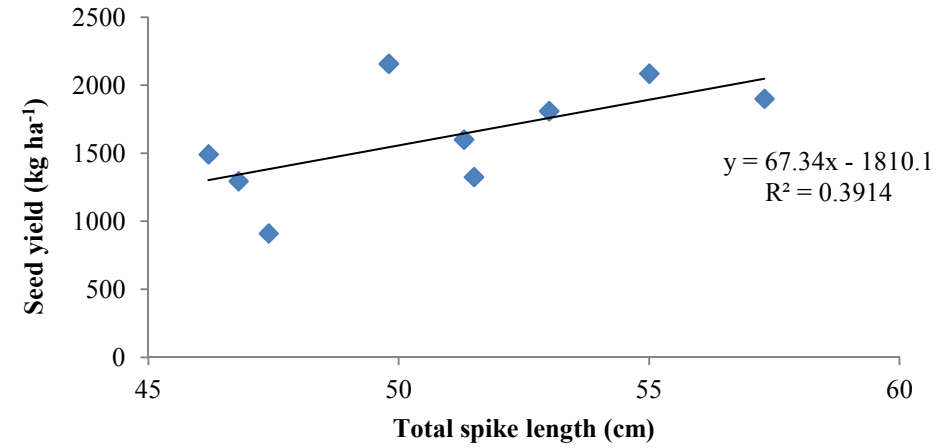


Fig. 1b. Relationship between total spike length and seed yield

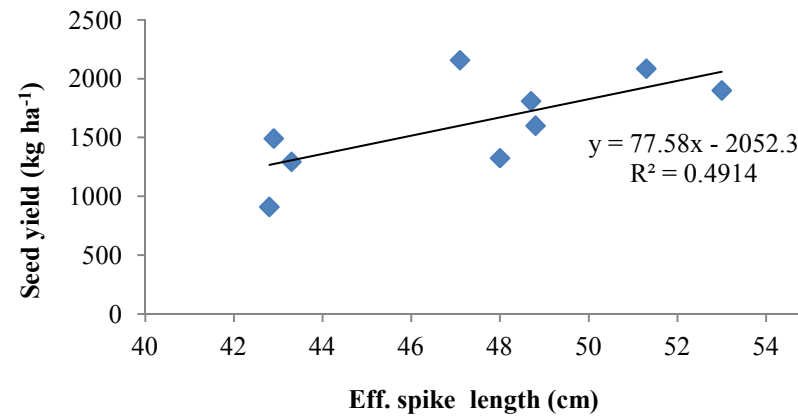


Fig. 1c. Relationship between effective spike length and seed yield

Fig. 1. Regression analysis between seed yield and yield influencing traits of post monsoon season castor

3.5 Correlation and Regression Analysis in Castor

Correlation studies showed that no. of branches/plant⁻¹ had a highly significant correlation with seed yield (0.822). The plants with more no. of branches/plant⁻¹ showed yield increase significantly. Similar results were also found when the crop was provided with an increased level of N by [11]. Further, no. of branches/plant⁻¹ had a significant and positive correlation with no. of spikes/plant⁻¹ (0.709) and no. of effective spikes/plant⁻¹ (0.656). Total spike length was significantly and positively correlated with effective spike length and seed yield. Similarly, no. of spikes/plant showed a positive correlation with no. of effective spikes/plant⁻¹ (Table 3). The strong positive correlation between seed yield and traits like branches/plant⁻¹, total spike length and effective spike length suggests that these traits are important for further selection of specific treatments or crop variety to enhance the total yield of this crop.

Regression analyses revealed a moderate to high positive relationship of branches/plant⁻¹ ($R^2 = 0.6756$), total spike length ($R^2 = 0.3914$) and effective spike length ($R^2 = 0.4914$) with seed yield. This suggested that these traits should be given the main emphasis for evolving high-yielding genotypes of castor. Among regression analyses of seed yield with all parameters studied, the highest value of regression coefficient ($b=1011.7$) was observed with no. of branches/plant (Fig. 1). This indicated that no. of branches/plant plays a significant role in increasing the seed yield of castor. The addition of nitrogen might have increased the vegetative growth resulting in a higher no. of branches/plant⁻¹ and finally higher seed yield. Increased no. of branches/plant⁻¹ and seed yield due to addition of mineral nutrition was also reported in castor [19].

4. CONCLUSION

The two year field study demonstrated that cultivation of castor hybrid PCH-111 or DCH-177 fertilized with 120 kg N ha⁻¹ could be the better option for enhancing castor production during post monsoon season on Alfisols. Further, hybrids were found superior to varieties in achieving higher yields and economic returns besides efficient utilization of irrigation water.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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