Evaluation and Identification of *Rabi* Castor Based Profitable Cropping Systems on Alfisols in Southern Telangana

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Authors’ contributions

The research 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 was aimed at identifying the *rabi* castor based profitable cropping systems for Alfisols of Southern Telangana Zone.

**Study design:** Split plot design with three replications

**Place and duration of study:** Regional Agricultural Research Station, Professor Jayashankar Telangana State Agricultural University, Palem, Telangana state, India during *rabi* season of 2010-11 and 2011-12.

**Methodology:** The experiment was laid out in a split plot design with five preceding crops (mung bean, fodder jowar, corn, pearlmillet and sesame) in main plots and four nitrogen levels of *rabi* castor in sub plots (0, 40, 80 and 120 kg N ha⁻¹). The growth parameters, yield attributes, seed yield, water use efficiency and economics were studied.

**Results:** The results showed that among different proceeding crops evaluated that significantly higher castor seed yield and castor equivalent yield were obtained when *rabi* castor was preceded...
by corn (1973 and 2931 and kg ha$^{-1}$) and mung bean (1868 and 2696 kg ha$^{-1}$) as compared to that of sesame (1672 and 2207 kg ha$^{-1}$), pearl millet (1823 and 2199 kg ha$^{-1}$) and fodder jowar (1783 and 2154 kg ha$^{-1}$). However, higher total system gross returns (Rs. 1,04,118 ha$^{-1}$) and net returns (Rs. 52,462 ha$^{-1}$) were accrued when rabi castor was grown after corn only, but, a higher B:C ratio was realized due to mung bean as a preceding crop (2.12). Though castor during rabi season responded similarly to 80 and 120 kg N ha$^{-1}$ in terms of castor seed yield (2275 and 2381 kg ha$^{-1}$) and castor equivalent yield (2887 and 3013 kg ha$^{-1}$), application of 120 kg N ha$^{-1}$-to castor resulted in accruing of higher system net returns (Rs. 60,638 ha$^{-1}$) and B:C ratio (2.27). However, the results of interaction further showed that rabi castor preceded by mung bean with the application of 80 kg N ha$^{-1}$ was found profitable (Rs. 75,573 ha$^{-1}$). It was closely followed by corn-caster system (Rs. 73,289 ha$^{-1}$).

Keywords: Economics; equivalent yield; nitrogen levels; preceding crops; rabi castor.

1. INTRODUCTION

Castor (Ricinus communis) is an important industrial and non-edible oilseed crop grown across wide ranging agro-climatic regions of the world. India is the global leader with maximum area (69.4%), production (85.8%) and productivity (1751 kg ha$^{-1}$) [1]. It's oil contains a hydroxy fatty acid known as ricinoleic acid to the tune of 85-90%, hence, is considered as a versatile industrial raw material [2]. Castor is predominantly grown on light textured Alfisols under rainfed conditions during kharif season in South India in general and Southern Telangana Zone (STZ) in particular. It's cultivation is threatened by mid or terminal season drought due to partial or complete failure of monsoon and also Botrytina gray rot (BGR) due to incessant rainfall coupled with high humidity of >85-90% resulting in low productivity of 500 to 600 kg ha$^{-1}$ [3,4]. Further, exponential horizontal expansion under Bt cotton and corn during kharif season in STZ has replaced the castor at a faster pace. However, castor being a commercial crop having immense export potential, is earning more than Rs. 4000 crores of foreign exchange in India. Hence, there is an imminent need to enhance castor area and productivity by growing it in rabi season during which BGR and moisture stress are altogether can be avoided. Rabi castor was proved to have given higher economic returns besides minimal risk of weed, pest and disease menace. It has to be sown on 1st October for achieving higher seed yield, profits and water use efficiency [5]. Though several crops such as cereals, millets, legumes and horticultural crops can be rotated with castor, it is essential to evaluate and suggest short duration and economically superior crop(s) during kharif season to facilitate sowing of rabi castor at optimum time and also for sustaining the productivity of the system. Hence, a field study was executed to evaluate and identify rabi castor based profitable cropping systems in rain starved Southern Telangana Zone.

2. MATERIALS AND METHODS

2.1 Characterization of Experimental Site

A research trial was conducted during rabi 2010-11 and 2011-12 at the Regional Agricultural Research Station, Professor Jayashankar Telangana State Agricultural University, Palem, Telangana state, India. The study site was located at 16°35' N latitude and 78°41'E longitude and an altitude of 642 above mean sea level (MSL) in Southern Telangana Zone (STZ). The experimental soil was near neutral with a pH of 6.6, low in organic carbon (0.32%) and available N (227 kg ha$^{-1}$), high in available P (75.7 kg P₂O₅ ha$^{-1}$) and K (420.3 kg K₂O ha$^{-1}$) as per the procedures suggested by [6-9].

2.2 Treatments, Agronomic Management and Statistical Design

The experiment was laid out in a split plot design (SPD) with five preceding crops (mung bean, fodder jowar, corn, pearl millet and sesame) in main plots and four nitrogen levels in sub plots (0, 40, 80 and 120 kg N ha$^{-1}$) in sub plots and replicated thrice (Fig. 1). The five preceding crops were sown on 28-06-2010 and 28-06-2011 on the receipt of soil profile soaking monsoon rains under rainfed conditions during kharif season, while rabi castor was sown on 05-10-2010 and 14-10-2011 under irrigated conditions as an irrigated dry (ID) crop, with recommended package of practices as furnished below in Table 1. A gross plot size of 5.4mx6.0m and a net plot size of 3.6 mx4.8m were maintained. Five
healthy plants with uniform growth were tagged from the net plot of each treatment to record the ancillary characters. Seed yield was recorded from the net plot, after harvesting and threshing of respective crops. While, in case of *rabi* castor, picking was done from three different order spikes during February and March months and the spikes were subjected to threshing. Seed from three pickings was gathered to have final seed yield. The water use efficiency (WUE; kg ha\(^{-1}\) mm\(^{-1}\)) was computed by dividing the castor equivalent yield with amount of water used by summing up the water applied for *rabi* castor and effective rainfall received during entire duration of respective cropping systems. The gross returns were calculated by multiplying the respective crop yield with market price and the net returns by deducting the cost of cultivation from gross returns. Further, the benefit:cost (B:C) was computed by dividing the gross returns with cost of cultivation.

The ancillary data was analysed using split plot design (SPD) with the help of OPSTAT software. The significance among the various treatments was determined using the t-test and the least significant differences (p=0.05) [10] to draw valid conclusions.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

A perusal of pooled data presented in Table 2 indicated that the growth parameters like plant height, no. of branches and nodes plant\(^{-1}\) of *rabi* castor were not significantly influenced by either various preceding crops or graded level of nitrogen.

3.2 Growth and Yield Attributes

The preceding crops failed to exert any significant influence on total and effective no. of spikes of *rabi* castor. Further, the castor produced significantly longer spikes when preceded by pearl millet as compared to other crops. Further, all the yield attributes like total and effective spike length, the total and effective no. of spikes plant\(^{-1}\) improved with graded levels of N and reached highest at 120 kg N ha\(^{-1}\). However, it was at par with 80 kg N ha\(^{-1}\) for effective spike length and effective no. of spikes plant\(^{-1}\) (Table 2).

3.3 Yield

*Rabi* castor seed yield was not significantly influenced by preceding crops. It might be due to non-significant difference for most of the growth and yield attributes except spike length. However, greater improvement in castor seed yield was witnessed due to nitrogen levels. The pooled data of two years in Table 3 indicated that significantly higher castor seed yield was obtained with the application of nitrogen at 120 kg N ha\(^{-1}\) (2381 kg ha\(^{-1}\)) over lower nitrogen levels (40 kg and 0), but, it was statistically at par with 80 kg N ha\(^{-1}\) (2275 kg ha\(^{-1}\)). The per cent yield improvement was 124.8% and 50.8% due to 120 kg N ha\(^{-1}\) over 40 kg N ha\(^{-1}\) and no N application, respectively. The probable reasons for such a positive response to 120 kg N ha\(^{-1}\) was the availability of nitrogen in synchrony with the crop which has resulted in better vegetative growth, root development, efficient photosynthesis, significantly longer and more no. of spikes resulting in greater seed yield of castor. The response of castor to higher levels of nitrogen supply was reported by several workers [11,12,13].

Significantly higher castor equivalent yield (CEY) was obtained when *rabi* castor was preceded by corn (2931 kg ha\(^{-1}\)) and mung bean (2696 kg ha\(^{-1}\)) as compared to that of sesame (2207 kg ha\(^{-1}\)), pearl millet (2199 kg ha\(^{-1}\)) and fodder jowar (2154 kg ha\(^{-1}\)). Similarly, castor responded up to 80 and 120 kg N ha\(^{-1}\) in terms of CEY (2887 and 3013 kg ha\(^{-1}\)). This was in tune with the findings of [12,13,14]. The per cent improvement in CEY was 82.4 and 37.1% due to 120 kg N ha\(^{-1}\) over 40 kg N ha\(^{-1}\) and control, respectively.

3.4 Water Use Efficiency

Significantly higher water use efficiency (WUE) was obtained when *rabi* castor was preceded by mung bean (2.66) and corn (2.65) which was due to significantly higher CEY as compared to that of pearl millet (2.17), fodder jowar and sesame (2.13). It means that mung bean-castor and corn-castor are water use efficient cropping systems on Alfisols. Among nitrogen levels, application of 120 kg N ha\(^{-1}\) resulted in significantly higher water use efficiency (2.91) over lower nitrogen levels (40 and 0), but, statistically at par with that of 80 kg N ha\(^{-1}\) (2.78) (Table 3).

3.5 Economic Analysis

Higher total system gross returns and net returns were realized when castor was preceded by corn (Rs. 1,04,118 and 52,462 ha\(^{-1}\)). It was closely followed by mung bean (Rs. 98,209 and 52,053 ha\(^{-1}\)) as compared to that of sesame (Rs. 83,711
and 37,555 ha\(^{-1}\), pearl millet (Rs. 78,986 and 33,330 ha\(^{-1}\)) and fodder jowar (Rs. 77,171 and 32,265 ha\(^{-1}\)). However, higher benefit:cost ratio was obtained from castor preceded by mung bean (2.12) and corn (2.01) (Table 3). It can be attributed to higher seed yield and CEY with mung bean/corn-castor systems than other. Further, higher total system gross and net returns and benefit:cost ratio (Rs. 1,08,513, 60,638 ha\(^{-1}\)and 2.27) were accrued with the supply of 120 kg N ha\(^{-1}\) to rabi castor. It was closely followed by 80 kg N ha\(^{-1}\). (Rs. 1,04,987, 57,600 ha\(^{-1}\) and 2.21). It was mainly due to higher castor seed yield and CEY at 120 and 80 kg N ha\(^{-1}\).

### 3.6 Interaction

Interaction between preceding crops and N applied to rabi castor revealed that castor responded significantly upto 80 kg N ha\(^{-1}\) only when preceded by corn and mung bean, but, upto 120 kg N ha\(^{-1}\) when preceded by sesame, fodder jowar and pearl millet, in respect of castor seed yield and CEY (Table 4 and 5). The same trend was observed with regard to WUE (Table 6), total system gross returns (Table 7), total system net returns (Table 8) and B:C ratio (Table 9). Similar observations were made earlier by few researchers [13,14,15]. The beneficial effect of legumes in a system has been thoroughly demonstrated in this field investigation. Further, the synergistic effect of legumes towards the improvement of yield can linked to the symbiotic fixation of atmospheric nitrogen which improved the nutrition of the plant [16]. Furthermore, it has been shown that legumes plays a positive role in the solubilization of phosphorus (P) and improves productivity.

![Fig. 1. Lay out the experimental field](image-url)
Table 1. Package of practices followed for different crops in the experiment

| S.No. | Name of the crop | Variety | Duration (days) | Spacing (cm x cm) | Seed rate (kg ha\(^{-1}\)) | Seed treatment (g or ml kg\(^{-1}\)) | Fertilizer schedule (kg N, P\(_2\)O\(_5\), K\(_2\)O ha\(^{-1}\)) | Weed control | Plant protection | Harvesting dates |
|-------|------------------|---------|-----------------|-------------------|-----------------------------|----------------------------------|----------------------------------|--------------|----------------|-------------------|
| Kharif
| 1 | Mung bean (MB) | MGG-295 | 80 | 30x10 | 20.0 | Imidachloprid (5) | Pre-em. application of Pendimethalin (5 ml lit\(^{-1}\)) followed by two hand weedings | Acephate (1.5 g lit\(^{-1}\)) | 17-09-2010 and 18-09-2011 |
| 2 | Fodder Jowar (FJ) | CSV 21F | 60 | 45x15 | Thiram (3) | 60-30-20 | Pre-em. application of Atrazine (5 g lit\(^{-1}\)) followed by two hand weedings | - | 01-09-2010 and 31-08-2011 |
| 3 | Corn (C) | DHM-117 | 95 | 60x20 | Carbenazim (3) | 180-60-60 | Pre-em. application of Atrazine (5 g lit\(^{-1}\)) followed by two hand weedings | Leaf blight (Dithane Z-78 @ 2.5 g lit\(^{-1}\)) | 30-09-2010 and 02-10-2011 |
| 5 | Pearl millet (PM) | PHB-3 | 80 | 45x15 | Thiram (3) | 60-30-20 | Pre-em. application of Atrazine (3 g lit\(^{-1}\)) followed by two hand weedings | - | 17-09-2010 and 15-09-2011 |
| 5 | Sesame (S) | YLM-17 | 80 | 45x10 | Imidachloprid (2) | 40-20-20 | Pre-em. application of Pendimethalin (3 ml lit\(^{-1}\)) followed by two hand weedings | Phyllody (Dimethoate @ 2 ml lit\(^{-1}\)) | 17-09-2010 and 15-09-2011 |
| Rabi
| 1 | Castor | PCH-111 | 150 | 90x60 | 5.0 | N as per treatment** | Pre-em. Application of Pendimethalin (5 ml lit\(^{-1}\)) followed by two times intercultivations and two intra row hand weedings | Leaf hopper (Acephate 1.5 g lit\(^{-1}\); Dimethoate 2.0 ml lit\(^{-1}\); Semilooper and Spodoptera (Novoluron 2.0 ml lit\(^{-1}\)) | February and March 2011 and 2012 |

Legend *Source: N: urea (46% N); P\(_2\)O\(_5\): Single super phosphate (SSP: 16% P\(_2\)O\(_5\)); K\(_2\)O: Muriate of potash (MOP: 60% K\(_2\)O). Corn: Nitrogen in three equal split doses at basal, knee high stage and flowering; entire phosphorus as basal, potash in equal splits with half as basal and half at flowering.

Fodder jowar: Nitrogen in two equal splits with half as basal and half at 30-35 DAS, entire phosphorus and potash as basal.

Sesame: Nitrogen in two equal splits with half as basal and half at 30 DAS, entire phosphorus and potash as basal.

Mung bean: Entire nitrogen and phosphorus basal.

**N dose was applied as per the treatment for rabi castor, with 50% N as basal and remaining 50% N in three equal split doses at 30, 60 and 90 DAS, entire phosphorus and potash as basal.
Table 2. Effect of N levels on growth and yield attributes of rabi castor grown after different kharif preceding crops (Pooled data of 2010-11 and 2011-12)

| Treatments | 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 |
|------------|-------------------|--------------------------|-----------------------|-------------------------|------------------------|------------------------|-------------------------------|
| Preceding crops |                    |                           |                       |                         |                        |                        |                               |
| Mung bean   | 63.4              | 3.22                     | 12.8                  | 46.8                    | 44.6                   | 7.63                   | 6.94                          |
| Fodder Jowar | 62.5              | 3.22                     | 11.8                  | 44.2                    | 42.6                   | 7.32                   | 6.69                          |
| Corn        | 63.1              | 3.12                     | 12.0                  | 47.5                    | 45.4                   | 7.51                   | 6.88                          |
| Pearl millet | 63.5              | 3.18                     | 12.5                  | 56.7                    | 53.8                   | 8.65                   | 7.73                          |
| Sesame      | 63.3              | 3.07                     | 13.2                  | 47.2                    | 45.0                   | 6.94                   | 6.04                          |
| SES±        | 3.1               | 0.28                     | 0.4                   | 1.7                     | 1.76                   | 0.56                   | 0.53                          |
| CD (0.05)   | NS                | NS                       | NS                    | 5.5                     | 5.74                   | NS                     | NS                            |

| N levels (kg ha⁻¹) | Treatments | 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 |
|--------------------|------------|-------------------|--------------------------|-----------------------|-------------------------|------------------------|------------------------|--------------------------------|
| 0                  | 59.4       | 2.95              | 12.9                     | 41.7                  | 39.9                    | 5.94                   | 5.46                          |
| 40                 | 64.6       | 3.19              | 12.7                     | 47.9                  | 45.5                    | 7.37                   | 6.61                          |
| 80                 | 64.5       | 3.19              | 12.2                     | 51.8                  | 49.7                    | 7.97                   | 7.27                          |
| 120                | 65.7       | 3.32              | 12.0                     | 52.4                  | 50.0                    | 8.99                   | 7.92                          |
| SES±               | 2.1        | 0.18              | NS                       | 1.2                   | 1.12                    | 0.32                   | 0.24                          |
| CD (0.05)          | NS         | NS                | NS                       | 3.4                   | 3.22                    | 0.93                   | 0.70                          |

Table 3. Effect of N levels on the productivity, WUE and economics of rabi castor grown after different kharif preceding crops (Pooled data of 2010-11 and 2011-12)

| Treatments | Castor seed yield (kg ha⁻¹) | Castor seed equivalent yield (kg ha⁻¹) | Water used (mm) | WUE (kg ha⁻¹ mm⁻¹) | Castor gross returns (Rs ha⁻¹) | Preceding crop gross returns (Rs ha⁻¹) | Total system gross returns (Rs ha⁻¹) | Total system net returns (Rs ha⁻¹) | B:C ratio |
|------------|-----------------------------|----------------------------------------|-----------------|-------------------|-----------------------------|----------------------------------------|--------------------------------------|------------------------------------|-----------|
| Preceding crops |                                |                                        |                 |                   |                             |                                        |                                      |                                    |           |
| Mung bean   | 1868                        | 2696                                   | 1013.9          | 2.66              | 68770                      | 29440                                  | 98209                                | 52053                             | 2.12      |
| Fodder Jowar| 1783                        | 2154                                   | 1013.9          | 2.13              | 65366                      | 11804                                  | 77171                                | 32265                             | 1.71      |
| Corn        | 1973                        | 2931                                   | 1116.3          | 2.65              | 70963                      | 31355                                  | 104118                               | 52462                             | 2.01      |
| Pearl millet| 1823                        | 2199                                   | 1013.9          | 2.17              | 65607                      | 13379                                  | 78986                                | 33330                             | 1.72      |
| Sesame      | 1672                        | 2207                                   | 1034.7          | 2.13              | 64391                      | 19321                                  | 83711                                | 37555                             | 1.81      |
| SES±        | 78                          | 86                                     | 0.08            | 2007              | 786                         | 2073                                  | 2073                                 | 0.04                               |           |
| CD (0.05)   | NS                          | 281                                    | 0.26            | NS                | 2568                       | 6752                                  | 6752                                 | 0.14                               |           |

| N levels (kg ha⁻¹) | Treatments | Castor seed yield (kg ha⁻¹) | Castor seed equivalent yield (kg ha⁻¹) | Water used (mm) | WUE (kg ha⁻¹ mm⁻¹) | Castor gross returns (Rs ha⁻¹) | Preceding crop gross returns (Rs ha⁻¹) | Total system gross returns (Rs ha⁻¹) | Total system net returns (Rs ha⁻¹) | B:C ratio |
|--------------------|------------|-----------------------------|----------------------------------------|-----------------|-------------------|-----------------------------|----------------------------------------|--------------------------------------|------------------------------------|-----------|
| 0                  | 1059       | 1652                        | 1038.5                                  | 1.59            | 39909             | 20633                      | 60541                                  | 15291                               | 1.34      |
| 40                 | 1578       | 2197                        | 1038.5                                  | 2.12            | 58233             | 21483                      | 79716                                  | 32591                               | 1.69      |
| 80                 | 2275       | 2887                        | 1038.5                                  | 2.78            | 83334             | 21652                      | 104987                                | 57612                               | 2.21      |
| 120                | 2381       | 3013                        | 1038.5                                  | 2.91            | 86602             | 21911                      | 108513                                | 60638                               | 2.27      |
| SES±               | 56         | 50                         | 0.05                                    | 1005            | 540               | 1132                       | 3269                                  | 3269                               | 0.02      |
| CD (0.05)          | 161        | 146                         | 0.14                                    | 2904            | NS                |                            |                                       |                                     | 0.07      |
### Table 4. Effect of interaction between preceding crops and N levels on castor seed yield (kg ha\(^{-1}\))

| Treatments          | Control | 40 kg N ha\(^{-1}\) | 80 kg N ha\(^{-1}\) | 120 kg N ha\(^{-1}\) | Average |
|---------------------|---------|---------------------|---------------------|----------------------|---------|
| Mung bean           | 1277    | 1443                | 2473                | 2278                 | 1868    |
| Fodder Jowar        | 993     | 1667                | 2103                | 2357                 | 1783    |
| Corn                | 993     | 1863                | 2557                | 2477                 | 1973    |
| Pearl millet        | 1007    | 1747                | 2140                | 2397                 | 1823    |
| Sesame              | 1033    | 1150                | 2103                | 2400                 | 1672    |
| Average             | 1059    | 1578                | 2275                | 2381                 |         |

N at same level of preceding crops: 156
Preceding crops at same level of N: 401

### Table 5. Effect of interaction between preceding crops and N levels on castor equivalent yield (kg ha\(^{-1}\))

| Treatments          | Control | 40 kg N ha\(^{-1}\) | 80 kg N ha\(^{-1}\) | 120 kg N ha\(^{-1}\) | Average |
|---------------------|---------|---------------------|---------------------|----------------------|---------|
| Mung bean           | 2017    | 2220                | 3345                | 3200                 | 2696    |
| Fodder Jowar        | 1980    | 2597                | 3450                | 2710                 | 2154    |
| Corn                | 1980    | 2833                | 3507                | 3403                 | 2931    |
| Pearl millet        | 1403    | 2133                | 2470                | 2790                 | 2199    |
| Sesame              | 1500    | 1703                | 2660                | 2963                 | 2207    |
| Average             | 1652    | 2197                | 2887                | 3013                 |         |

N at same level of preceding crops: 172
Preceding crops at same level of N: 397

### Table 6. Effect of interaction between preceding crops and N levels on system WUE (kg ha\(^{-1}\)mm\(^{-1}\))

| Treatments          | Control | 40 kg N ha\(^{-1}\) | 80 kg N ha\(^{-1}\) | 120 kg N ha\(^{-1}\) | Average |
|---------------------|---------|---------------------|---------------------|----------------------|---------|
| Mung bean           | 1.99    | 2.19                | 3.30                | 3.16                 | 2.66    |
| Fodder Jowar        | 1.34    | 2.07                | 2.42                | 2.67                 | 2.13    |
| Corn                | 1.80    | 2.56                | 3.17                | 3.09                 | 2.65    |
| Pearl millet        | 1.38    | 2.10                | 2.44                | 2.76                 | 2.17    |
| Sesame              | 1.45    | 1.65                | 2.57                | 2.86                 | 2.13    |
| Average             | 1.59    | 2.12                | 2.78                | 2.91                 |         |

N at same level of preceding crops: 0.16
Preceding crops at same level of N: 0.33

SEm± CD (0.05)
Table 7. Effect of interaction between preceding crops and N levels on total system gross returns (Rs ha\(^{-1}\))

| Treatments          | Control   | 40 kg N ha\(^{-1}\) | 80 kg N ha\(^{-1}\) | 120 kg N ha\(^{-1}\) | Average |
|---------------------|-----------|----------------------|---------------------|----------------------|---------|
| Mung bean           | 73696     | 81111                | 122198              | 11532                | 98209   |
| Corn                | 70419     | 102140               | 125414              | 118498               | 104118  |
| Pearl millet        | 52147     | 79678                | 86620               | 97500                | 78986   |
| Sesame              | 57276     | 60254                | 102554              | 114761               | 83711   |
| Average             | 60541     | 79716                | 104987              | 108513               |         |

Market price: Castor: Rs. 38.00 kg\(^{-1}\) seed; Mung bean: Rs. 34.00 kg\(^{-1}\) seed; Fodder Jowar: Rs. 2.00 kg\(^{-1}\) green fodder; Corn: Rs. 9.25 kg\(^{-1}\) seed; Pearl millet: Rs. 10.50 kg\(^{-1}\) seed; Sesame: 55.00 kg\(^{-1}\) seed

Table 8. Effect of interaction between preceding crops and N levels on total system net returns (Rs ha\(^{-1}\))

| Treatments          | Control   | 40 kg N ha\(^{-1}\) | 80 kg N ha\(^{-1}\) | 120 kg N ha\(^{-1}\) | Average |
|---------------------|-----------|----------------------|---------------------|----------------------|---------|
| Mung bean           | 29196     | 34736                | 75573               | 68707                | 52053   |
| Corn                | 20419     | 50265                | 73289               | 65873                | 52462   |
| Pearl millet        | 8147      | 33803                | 40495               | 50875                | 33330   |
| Sesame              | 12776     | 13879                | 55929               | 67636                | 37555   |
| Average             | 15291     | 32591                | 57612               | 60638                |         |

Table 9. Effect of interaction between preceding crops and N levels on B:C ratio of the system

| Treatments          | Control   | 40 kg N ha\(^{-1}\) | 80 kg N ha\(^{-1}\) | 120 kg N ha\(^{-1}\) | Average |
|---------------------|-----------|----------------------|---------------------|----------------------|---------|
| Mung bean           | 1.66      | 1.75                 | 2.62                | 2.46                 | 2.12    |
| Corn                | 1.14      | 1.87                 | 1.94                | 2.09                 | 1.71    |
| Pearl millet        | 1.19      | 1.74                 | 1.88                | 2.09                 | 2.01    |
| Sesame              | 1.29      | 1.30                 | 2.20                | 2.43                 | 1.81    |
| Average             | 1.34      | 1.89                 | 2.21                | 2.27                 |         |

Market price: Castor: Rs. 38.00 kg\(^{-1}\) seed; Mung bean: Rs. 34.00 kg\(^{-1}\) seed; Fodder Jowar: Rs. 2.00 kg\(^{-1}\) green fodder; Corn: Rs. 9.25 kg\(^{-1}\) seed; Pearl millet: Rs. 10.50 kg\(^{-1}\) seed; Sesame: 55.00 kg\(^{-1}\) seed
4. CONCLUSION

Growing *rabi* castor with mung bean or corn as preceding crop and fertilized with 80 kg N ha\(^{-1}\) can be recommended on light textured Alfisols of Southern Telangana for realizing significantly higher system productivity and economic benefits besides water use efficiency. Further, castor grown after fodder jowar, sesame and pearl millet demanded higher N with less economic returns, hence, can't be advocated.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. FAO. Food and Agriculture Organisation of the United Nations. Rome, Italy; 2019.
2. Gudadhe JD, Thanki RM, Pankhaniya RB, Ardesha VG. Response of *Rabi* hybrid castor to rate and source of nitrogen with and without biofertiliser. Indian Journal of Fertilizers. 2017;13 (7):42-46.
3. Ramanjaneyulu AV, Dharma Reddy K, Vishnuvardhan Reddy A, Nagesh Kuma MV, KhayumAhmed S, Gouri Shankar V, Neelima, TL. Upscaling and outscaling of *rabi* castor in Andhra Pradesh-opportunities and limitations. International Journal of Bio-resource and Stress Management. 2014;5(1):138-142.
4. Madhu M, Venkataramana M, Performance *rabi* castor (*Ricinus communis* L) under zero-tilled condition after different preceding crops. Journal of Oilseeds Research. 2017a;34(2):89-92.
5. Ramanjaneyulu AV, Vishnuvardhan Reddy A, Madhavi A. The impact of sowing date and irrigation regime on castor (*Ricinus communis* L) seed yield, oil quality characteristics and fatty acid composition during post rainy season in South India. Industrial Crops and Products. 2013;44:25-31.
6. Jackson ML. Soil chemical analysis (2nd Ed.). Prentice Hall of India, New Delhi. 1973;498.
7. Walkley A, Black IA. An examination of the Degtareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 1934;37:29-38.
8. Olsen SR, Cole CW, Watanabe RS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium carbonate. US Department of Agriculture, 1954;2:939.
9. Subbaiah BV, Asija GL. A rapid procedure for estimation of available nitrogen in soils. Current Science. 1956;65(7):477-480.
10. Panse VG, Sukhatme PV. Statistical methods for Agricultural workers. ICAR Publication. New Delhi. 1985;296.
11. Patel RM, Patel MM, Patel, GN. Effect of spacing and nitrogen levels on *rabi* castor, *Ricinus communis* grown under different cropping sequences in north Gujarat agro-climatic condition. Journal of Oilseeds Research. 2009;26(2):123-125.
12. Shinde RS, Kalegore NK, Gagare Yogini, M. Effect of plant spacing and fertilizer levels on yield and yield attributes of castor (*Ricinus communis* L.). International Journal Current Microbiological Applied Sciences. 2018;6:1738-1743.
13. Bhargavi B, Sree Rekha M, Prasad PVN, Jayalalitha K. Growth and yield of castor hybrids at varying nitrogen levels in Andhra Pradesh, India. International Journal Current Microbiological Applied Sciences. 2018;7(8):3178-3183.
14. Madhu M, Venkata Ramana M, Sidevi S. Economics of zero-till *rabi* castor (*Ricinus communis* L.) under the influence of different preceding crops. Indian Journal of Dry land Agriculture & Development. 2017b;32(2):13-17.
15. Patel KS, Patel GN, Patel MK, Pathak, HC, Patel JK. Nitrogen requirement of *rabi* castor, *Ricinus communis* L. under different crop sequences. Journal of Oilseeds Research. 2005;22 (1):209-210.
16. Odhiambo GD, Ariga ES. Effect of intercropping corn and beans on Striga incidence and grain yield, Seventh Eastern and Southern Africa Regional Corn Conference. 2001;183-186.

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