Planter performance under varied seed rate and nutrient management in chickpea (Cicer arietinum)

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ABSTRACT

A field study was carried out during winter (rabi) seasons of 2020–21 and 2021–22 at Agricultural Research Institute, Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana to evaluate planter performance in chickpea (Cicer arietinum L.). Experiment was laid in split plot design with 4 seed rates (52, 70, 77 and 105 kg/ha) with corresponding two inter and intra row spacings (30, 40 and 7.5, 10 cm) in main plots and 7 nutrient management treatments in sub plots, viz. Absolute control, 75, 100, 125% RDF, 75% RDF + Microbial consortia (MC) – Azotobacter + Phosphorus solubilizing bacteria + Potassium releasing bacteria + Zinc solubilizing bacteria (5 kg/ha), 100% RDF + MC and 125% RDF+MC. Results revealed that miss and multiple indices were 11.31 and 10.25 and 4.89 and 4.51% for 10 cm spacing and 7.21 and 6.00 and 5.12 and 5.19% for 7.5 cm spacing during 2020–21 and 2021–22. Higher energy use efficiency (4.64), energy intensiveness (1.61 MJ/₹), net energy benefit (58106.4 MJ/ha) and energy efficiency ratio (2.37) were with 105 kg/ha seed rate and higher specific energy (8.91 MJ/ha) was with 52 kg /ha. Among nutrient management, highest energy use efficiency (4.98) and energy efficiency ratio were with absolute control while, 125% RDF + MC resulted in higher energy intensiveness (1.61 MJ/₹) and net energy benefit (54365.1 MJ/ha). Higher specific energy and agro-chemical energy ratio was with 75% RDF (7.94 MJ/ha) and 125% RDF (0.48). Among seed rate, yield (seed and haulm) and energy indices were highest with 105 kg/ha and among nutrient management, highest yield and energy indices were with 125% RDF + MC but, on par with 100% RDF + MC and 125% RDF treatments.

Keywords: Chickpea, Energy indicators, Input-use, Multiple indices, Yield

Agriculture, is the chief occupation for about one-half of Indian population. Farmers on an average spend about 30% of revenue on fertilizers and labour- the biggest challenge for future farming. With increase in labour scarcity and wages there is a dire need to switch towards mechanization (Shilpa et al. 2017). Mechanization helps to reduce drudgery, enable crop diversification, enhance cropping intensity, ensure timeliness and efficiency (Bhardwaj 2014). Mechanical planters ensure uniform plant stand and sowing depth, apart from reduced cost of cultivation by eliminating thinning and gap filling and covers larger area in short period in economical way. Mechanization can be practiced in chickpea (Cicer arietinum L.) for various operations (Sowing, spraying, harvesting and threshing) (Dhimate et al. 2018). Among various management practices, optimum plant population and balanced nutrient management are key players deciding the yield. Seed rate differs for mechanical sowing based on cultivar and fertilizer dose needs to be redesigned in accordance with plant density (Sujathamma and Babu 2019). Hence, there is an urgent need for standardization of optimum plant density and nutrient management for machine planted chickpea to achieve higher yields. Modern agriculture system relies on energy inputs (fertilizers, fossils fuel, pesticides and electricity) that affect our ecosystem health. Agriculture being producer and consumer of energy (Taheri Garav et al. 2010); input - output analysis of energy is key to quantify efficient energy use the crux of sustainable agriculture (Morteza et al. 2012). With this drawback, present study was carried out to evaluate performance of CIAE planter under varying seed rate and nutrient management in chickpea.

MATERIALS AND METHODS

Experiment was conducted during winter (rabi) seasons of 2020–21 and 2021–22 at the research farm of Agricultural Research Institute, Professor Jayashankar Telangana State Agricultural University, Hyderabad (17° 19′41″N, 78°23′48″E and altitude of 494 m amsl), Telangana. Experimental soil was sandy clay loam, pH (8.31), low, medium and high in available nitrogen, phosphorus and potassium (176, 73 and 524 kg/ha respectively). Experiment was laid in split plot design with 4 seed rates (52, 70, 77 and 105 kg/ha) with corresponding two inter and intra row spacings (30, 40 and 7.5, 10 cm) in main plots and 7 nutrient management treatments in sub plots, viz. Absolute control, 75, 100, 125% RDF, 75% RDF + Microbial consortia (MC) – Azotobacter + Phosphorus solubilizing bacteria + Potassium releasing bacteria + Zinc solubilizing bacteria (5 kg/ha), 100% RDF + MC and 125% RDF+MC. Results revealed that miss and multiple indices were 11.31 and 10.25 and 4.89 and 4.51% for 10 cm spacing and 7.21 and 6.00 and 5.12 and 5.19% for 7.5 cm spacing during 2020–21 and 2021–22. Higher energy use efficiency (4.64), energy intensiveness (1.61 MJ/₹), net energy benefit (58106.4 MJ/ha) and energy efficiency ratio (2.37) were with 105 kg/ha seed rate and higher specific energy (8.91 MJ/ha) was with 52 kg /ha. Among nutrient management, highest energy use efficiency (4.98) and energy efficiency ratio were with absolute control while, 125% RDF + MC resulted in higher energy intensiveness (1.61 MJ/₹) and net energy benefit (54365.1 MJ/ha). Higher specific energy and agro-chemical energy ratio was with 75% RDF (7.94 MJ/ha) and 125% RDF (0.48). Among seed rate, yield (seed and haulm) and energy indices were highest with 105 kg/ha and among nutrient management, highest yield and energy indices were with 125% RDF + MC but, on par with 100% RDF + MC and 125% RDF treatments.

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design with 4 seed rates (52, 70, 77 and 105 kg/ha) in main plots with corresponding planting density (2.22, 2.96, 3.33 and 4.44 lakh plants/ha). CIAE Incline plate planter was calibrated (variety JG-11) in Engineering workshop (Sahay 2010a) to obtain desired seed rate for four planting densities, viz. 2 inter row (45 and 30 cm) and 2 intra row spacings (7.5 and 10 cm) by using seed metering plates (18 and 16 cells) fabricated in workshop. Seven nutrient management treatments in sub-plot treatments were S₁, Absolute control (0- N, P and K); S₂, 75% RDF; S₃, 100% RDF (20:50:20 N, P₂O₅ and K₂O kg/ha); S₄, 125% RDF; S₅, 75% RDF + Microbial consortia (MC) - Azotobacter + Phosphorus solubilizing bacteria + Potassium releasing bacteria + Zinc solubilizing bacteria @5 kg/ha; S₆, 100% RDF + MC; and S₇, 125% RDF + MC and replicated thrice. Total P (Single super phosphate), K (Muriate of potash) and 50% N (urea) were applied as basal while, remaining 50% N was top dressed 30 days after sowing. Basal application of 75 kg of vermicompost was done uniformly in all plots with 750 g (Rhizobium, Trichoderma viridae and Pseudomonas sp) against fungal diseases. Data were statistically analyzed using analysis of variance technique as outlined by Gomez and Gomez (1984).

Planter and operational parameters: Plant stand and associated plant spacing distribution in field were recorded up to 15 days after sowing and used to calculate planter performance parameters, viz. mean seed spacing, miss index (Bracy et al. 1999), multiple index (Katchman and Smith 1995), effective field efficiency (Sahay 2010a) and field capacity Sahay (2010b).

Energy indicators: Energy use efficiency, specific energy, energy intensiveness, net energy benefit, agrochemical energy ratio and energy efficiency ratio were calculated based on energy equivalents of inputs and outputs (Table 1) as per Khan et al. (2009), Moradi et al. (2018) and Soni et al. (2018).

Energy indicators were calculated based on standard references: Human Labour – men (Yousefi and Damghani 2012) and women (Thyagaraj 2012); machiney nitrogen (Nassiri and Singh 2009); agrochemicals (Tzilivakis et al. 2005, Nassiri and Singh 2009, Kitani 1999); fertilizers and manures (Devasenapathy et al. 2009, Kizilaslan 2009, Akcaoz et al. 2009); seed (Kitani 1999); diesel (Thyagaraj 2012); petrol (Kitani 1999); irrigation (Nassiri and Singh 2009, Mohammadi and Omid 2010); and for outputs (Thyagaraj 2012) respectively.

RESULTS AND DISCUSSION

Planter performance parameters

Mean seed spacing: It was measured using 16 and 18 cells seed metering plate along each planted row and was 9.4 and 7.9 cm as against theoretical spacing of 10 and 7.5 cm during 2020–21 and 9.5 and 7.5 cm during 2021–22 (Table 1). Mean seed spacing was within range of optimal theoretical seed spacing of 10 and 7.5 cm (Singh et al. 2012).

Miss index: It was 11.31 and 10.25% for 10 cm while, 7.21 and 6.00% for 7.5 cm spacing during 2020–21 and 2021–22 respectively (Table 1). This level of miss index could be due to number of factors like seed metering plate, failure of metering plate to be filled with seeds, clogging of seeds in the metering plate and failure in dropping holes (Bozdogan 2008).

Multiple index: It ranged between 4.89 and 4.51% for 10 cm spacing and 5.12 and 5.19% for 7.5 cm during 2020–21 and 2021–22 respectively. This result might be a result of seed dropping from the metering plate or drop tube (Kumar 2019).

Effective field efficiency and field capacity: Field capacity was calculated considering the productive time required for field operation and was 0.41 and 0.38 ha/h while, the effective field efficiency was 77.35 and 71.70%.
during 2020–21 and 2021–22 respectively (Table 1). These characteristics depend on planter operational speed and theoretical width covered by implement. The values indicate a satisfactory performance as they were within the range (Kepner et al. 1978).

Energy indicators: It is evident that both seed rate and nutrient management significantly influenced energy use efficiency, specific energy, energy intensiveness, net energy benefit (Table 2 and 3), energy efficiency ratio and agrochemical energy ratio during both the years.

Analysis of input energy use: Highest share of energy-use was for fertilizers and manures (36.79%) followed by fuel (21.96%) and irrigation (20.81%) (Fig 1) indicated that fertilizer inputs consumed highest energy (Sarkar et al. 2021). Thus, it necessitates the reduction of mineral fertilizers usage and substitution with biofertilizers. Next highest share by fuel might be due to mechanized operations and irrigation as crop was grown in irrigated eco-system. While, the least share of energy-use was for labour (0.60%) owing to mechanized operations (sowing, weeding and harvesting) that reduced drudgery and energy use through labour (Patil et al. 2016).

Energy use efficiency: Significantly higher energy use efficiency was with seed rate of 105 kg/ha (4.48 and 4.80) but at par with 77 kg/ha (4.11 and 4.47) during both the years. Higher energy use efficiency with higher seed rate was due to higher proportion of increase in energy output in terms of seed and haulm yield with low proportion of increase in energy input (Mangal et al. 2017).

Among nutrient management, absolute control recorded significantly higher energy use efficiency (4.83 and 5.13) during 2020–21 and 2021–22 (Fig 1) since, inorganic fertilizer inputs consume highest energy and conjunctive use of inorganics and biofertilizers enhanced energy balance and energy use efficiency (Sarkar et al. 2021).

Specific energy: Seed rate of 52 kg/ha resulted in during 2020–21 and 2021–22 respectively (Table 1). These characteristics depend on planter operational speed and theoretical width covered by implement. The values indicate a satisfactory performance as they were within the range (Kepner et al. 1978).

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### Table 2 Energy use efficiency, specific energy and energy intensiveness under varied seed rate and nutrient management

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Energy use efficiency</th>
<th>Specific energy (MJ/ha)</th>
<th>Energy intensiveness (MJ/₹)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main plot-Seed rate (M)</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>M₁, 52 kg/ha</td>
<td>3.30</td>
<td>3.51</td>
<td>3.41</td>
</tr>
<tr>
<td>M₂, 70 kg/ha</td>
<td>3.73</td>
<td>4.00</td>
<td>3.86</td>
</tr>
<tr>
<td>M₃, 77 kg/ha</td>
<td>4.11</td>
<td>4.47</td>
<td>4.29</td>
</tr>
<tr>
<td>M₄, 105 kg/ha</td>
<td>4.48</td>
<td>4.80</td>
<td>4.64</td>
</tr>
<tr>
<td>SEm±</td>
<td>0.07</td>
<td>0.10</td>
<td>0.06</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>0.25</td>
<td>0.35</td>
<td>0.21</td>
</tr>
<tr>
<td><strong>Sub plot-Nutrient management (S)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S₁, Absolute control</td>
<td>4.83</td>
<td>5.13</td>
<td>4.98</td>
</tr>
<tr>
<td>S₂, 75% RDF</td>
<td>3.72</td>
<td>3.98</td>
<td>3.85</td>
</tr>
<tr>
<td>S₃, 100% RDF</td>
<td>3.65</td>
<td>3.97</td>
<td>3.81</td>
</tr>
<tr>
<td>S₄, 125% RDF</td>
<td>3.64</td>
<td>3.92</td>
<td>3.78</td>
</tr>
<tr>
<td>S₅, 75% RDF + MC</td>
<td>3.90</td>
<td>4.17</td>
<td>4.00</td>
</tr>
<tr>
<td>S₆, 100% RDF + MC</td>
<td>3.83</td>
<td>4.10</td>
<td>3.99</td>
</tr>
<tr>
<td>S₇, 125% RDF + MC</td>
<td>3.77</td>
<td>4.09</td>
<td>3.93</td>
</tr>
<tr>
<td>SEm±</td>
<td>0.15</td>
<td>0.15</td>
<td>0.10</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>0.44</td>
<td>0.42</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Interaction (M × S) | SEm± | 0.30 | 0.29 | 0.20 | 0.66 | 0.31 | 0.38 | 0.11 | 0.10 | 0.07 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Interaction (S × M) | SEm± | 0.31 | 0.29 | 0.21 | 0.69 | 0.29 | 0.39 | 0.11 | 0.10 | 0.07 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS |
significantly higher specific energy (9.27 and 8.55 MJ/ha) during both the years due to lower yields registered with lower seed rate (Priya et al. 2019).

Among nutrient management, 75% RDF registered significantly higher specific energy (8.23 and 7.66 MJ/ha) during both the years due to lower yields registered with lower seed rate (Priya et al. 2019).

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nutrient management practices, 125% RDF + MC resulted in significantly higher net energy benefit of 51681.0 and 57043.3 MJ/ha during 2020–21 and 2021–22. While, significantly higher energy efficiency ratio was obtained with 100% RDF + MC (2.00 and 2.12) followed by 125% RDF + MC (1.98 and 2.10) during both the years. Higher number of plants per unit area along with higher dose of fertilizer increased energy gain and energy efficiency ratio (Priya et al. 2019).

Agrochemical energy ratio: It remained constant (0.38) for all seed rates during both the years due to use of common dose of chemicals under all seed rate treatments.

Among nutrient management, higher agrochemical energy ratio was with higher fertilizer rate (125% RDF). Agrochemical energy ratio was unaltered as biofertilizer addition was not taken into consideration (Patil and Ramesha 2017).

Seed and haulm yield: Significantly higher seed and haulm yield were registered with seed rate of 105 kg/ha (Fig 3) due to optimum plant number per unit area over corresponding lower seed rates (Patil et al. 2021).

Among the nutrient management practices, application of 125% RDF + MC resulted in significantly higher seed and haulm yield but, remained par with 125 and 100% RDF + MC. Increased yields under conjunctive use of 100% RDF and microbial consortia was due adequate amount and available form of nutrients that favoured better root growth and development and nutrient uptake (Sangma and Changde 2020).

It can be concluded that inter row spacing of 30 cm and closer intra row spacing of 7.5 cm was suitable for machine operations. Energy efficiency and yield levels were higher with seed rate of 105 kg/ha. Among nutrient management practices, conjuction of lower rate of inorganics along with biofertilizers increased efficiency of energy use. Energy intensity in economic terms also indicated that application of 100% RDF + microbial consortia helped in reaping higher yields apart from sustainable energy use.

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Fig 3 Seed and haulm yield of machine planted chickpea under varied seed rate and nutrient management.


