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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, *p*H (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

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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 S_1, Absolute control (0- N, P and K); S_2, 75% RDF; S_3, 100% RDF (20:50:20 N, P_2O_5 and K_2O kg/ha); S_4, 125% RDF; S_5, 75% RDF + Microbial consortia (MC) - *Azotobacter* + Phosphorus solubilizing bacteria + Potassium releasing bacteria + Zinc solubilizing bacteria @5 kg/ha; S_6, 100% RDF + MC; and S_7, 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); machineries (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%

Table 1 Details of conditions under which sowing was done with CIAE inclined plate planter and planter parameters

S.No.	Test condition	Particulars
I	Seed characteristics	
a.	Shape of seed	Spherical
b.	Weight of 100 seed (g)	21.93
II	Field condition	
a.	Location	ARI, Main farm, Rajendranagar
b.	Length of field (m)	90
c.	Width of the field (m)	18
d.	Type of soil	Sandy clay loam
e.	Method of preparation of field	Disc plough followed by cultivator and rotavator
III	Operational parameters	
a.	Row spacing (cm)	45 and 30
b.	Intra row spacing (cm)	10 and 7.5
c.	Depth of seed placement (cm)	4.5 (Adjustable)
IV	Specifications of power source	
a.	Make and Model	Mahindra
b.	Rated power (Hp)	25
c.	Forward speed (kmph)	1.9 (2020–21) and 1.8 (2021–22)

Particulars of planter parameters	*Intra row spacing*			
	10.0 cm		7.5 cm	
	2020–21	2021–22	2020–21	2021–22
Mean seed spacing (cm)	9.40	7.90	9.50	7.50
Miss index (%)	11.31	10.25	7.21	6.00
Multiple index (%)	4.89	4.51	5.12	5.19
Field capacity (ha/h)	0.41	0.38	0.41	0.38
Effective field efficiency (%)	77.35	71.7	77.35	71.7

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

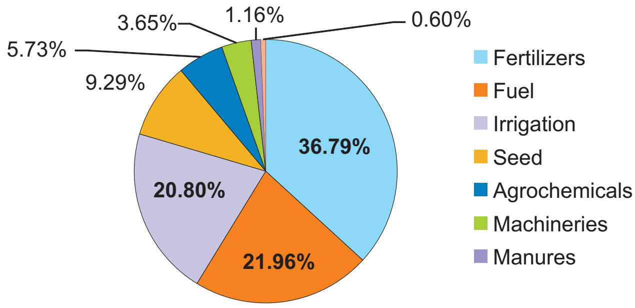

Fig 1 Source-wise share of energy input in machine planted chickpea production system.
Input analysis was done for recommended seed rate and nutrient dose for chickpea.

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

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

Treatment	Energy use efficiency			Specific energy (MJ/ha)			Energy intensiveness (MJ/₹)		
	2020–21	2021–22	Mean	2020–21	2021–22	Mean	2020–21	2021–22	Mean
Main plot-Seed rate (M)									
M_1, 52 kg/ha	3.30	3.51	3.41	9.27	8.55	8.91	1.29	1.31	1.30
M_2, 70 kg/ha	3.73	4.00	3.86	7.90	7.32	7.61	1.45	1.48	1.47
M_3, 77 kg/ha	4.11	4.47	4.29	7.27	6.64	6.96	1.48	1.53	1.50
M_4, 105 kg/ha	4.48	4.80	4.64	6.51	6.16	6.34	1.59	1.63	1.61
SEm±	0.07	0.10	0.06	0.18	0.15	0.10	0.02	0.04	0.02
CD (P=0.05)	0.25	0.35	0.21	0.64	0.51	0.33	0.08	0.13	0.07
Sub plot-Nutrient management (S)									
S_1, Absolute control	4.83	5.13	4.98	6.47	6.16	6.31	1.32	1.33	1.32
S_2, 75% RDF	3.72	3.98	3.85	8.23	7.66	7.94	1.36	1.39	1.38
S_3, 100% RDF	3.65	3.97	3.81	8.22	7.56	7.90	1.45	1.49	1.47
S_4, 125% RDF	3.64	3.92	3.78	8.20	7.39	7.80	1.57	1.63	1.60
S_5, 75% RDF + MC	3.90	4.17	4.00	7.85	7.21	7.53	1.40	1.41	1.40
S_6, 100% RDF + MC	3.83	4.10	3.99	7.62	7.10	7.36	1.49	1.55	1.52
S_7, 125% RDF + MC	3.77	4.09	3.93	7.56	7.10	7.33	1.58	1.64	1.61
SEm±	0.15	0.15	0.10	0.35	0.15	0.20	0.06	0.05	0.04
CD (P=0.05)	0.44	0.42	0.29	1.00	0.43	0.57	0.16	0.14	0.10
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

Table 3 Net energy benefit, energy efficiency ratio and agrochemical energy ratio under varied seed rate and nutrient management

Treatment	Net energy benefit (MJ/ha)			Energy efficiency ratio			Agrochemical energy ratio		
	2020–21	2021–22	Mean	2020–21	2021–22	Mean	2020–21	2021–22	Mean
Main plot-Seed rate (M)									
M_1, 52 kg/ha	36328.3	39324.0	37826.2	1.65	1.73	1.69		0.38	
M_2, 70 kg/ha	44169.0	47666.0	45917.5	1.91	2.03	1.97			
M_3, 77 kg/ha	48105.8	52735.1	50420.4	2.08	2.25	2.17			
M_4, 105 kg/ha	55697.5	60515.2	58106.4	2.34	2.41	2.37			
SEm±	827.8	1663.0	827.4	0.04	0.04	0.02			
CD (P=0.05)	2864.5	5754.9	2863.3	0.15	0.15	0.09			
Sub plot-Nutrient management (S)									
S_1, Absolute control	40862.4	43421.5	42051.9	2.44	2.49	2.47	0.09	0.09	0.09
S_2, 75% RDF	42049.1	45335.0	43692.0	1.87	1.97	1.92	0.37	0.38	0.38
S_3, 100% RDF	45001.8	49081.1	47041.5	1.83	1.94	1.89	0.43	0.44	0.44
S_4, 125% RDF	49386.7	54692.8	52039.7	1.88	2.03	1.95	0.48	0.48	0.48
S_5, 75% RDF + MC	45059.8	47477.8	46268.8	1.97	2.07	2.02	0.37	0.38	0.38
S_6, 100% RDF + MC	48485.2	53542.9	51014.1	2.00	2.12	2.06	0.43	0.44	0.44
S_7, 125% RDF + MC	51681.0	57049.3	54365.1	1.98	2.10	2.04	0.48	0.49	0.48
SEm±	2365.3	2249.4	1536.5	0.09	0.04	0.05	-	-	-
CD (P=0.05)	6725.8	6396.1	4368.9	0.26	0.11	0.15	-	-	-
Interaction (M × S)									
SEm±	4457	4485	2963	0.177	0.083	0.10	-	-	-
CD (P=0.05)	NS	NS	NS	NS	NS	NS	-	-	-
Interaction (S × M)									
SEm±	4731	4499	3073	0.186	0.076	0.11	-	-	-
CD (P=0.05)	NS	NS	NS	NS	NS	NS	-	-	-

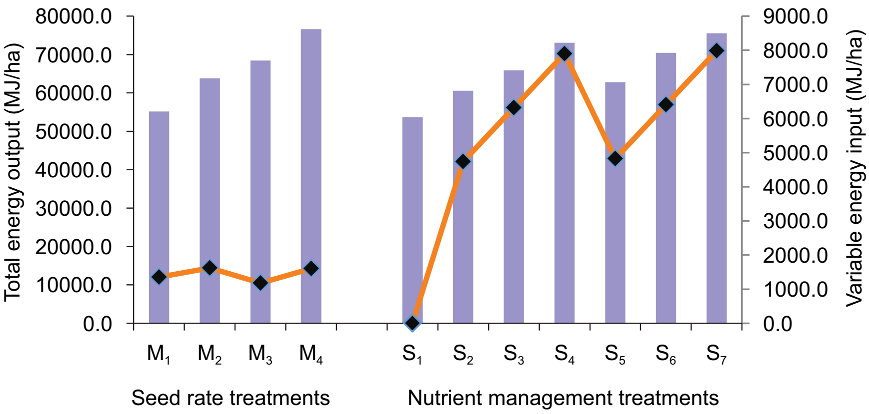

Fig 2 Variable energy input and total energy output (MJ/ha) of machine planted chickpea production system under varied seed rate and nutrient management.
Common energy input of 9262 and 9040 MJ/ha was used during 2020–21 and 2021–22 respectively. Variable energy for seed rate treatment includes seed cost and weeding cost; nutrient management treatments include energy for fertilizers and microbial consortia.

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) while, lowest was with absolute control (6.47 and 6.16) during both the years (Fig 2). This infers that sole application of chemical fertilizers increased energy use for producing per unit seed yield.

Energy intensiveness: Seed rate of 105 kg/ha resulted in significantly higher energy intensiveness (1.60 and 1.64 MJ/₹) during 2020–21 and 2021–22 due to higher energy output in terms of seed and haulm as compared to corresponding lower seed rate.

Among the nutrient management practices, application of 125% RDF + MC resulted in significantly higher energy intensiveness (1.59 and 1.66 MJ/₹) followed by 125% RDF and 100% RDF + MC due to increased energy output in terms of yield recorded in respective treatments (Deva and Kolhe 2018).

Net energy benefit and energy efficiency ratio: Significantly higher net energy benefit and energy efficiency ratio was with 105 kg/ha seed rate (55697.5 and 60515.2 MJ/ha, 2.34 and 2.41) during the both the years. Among

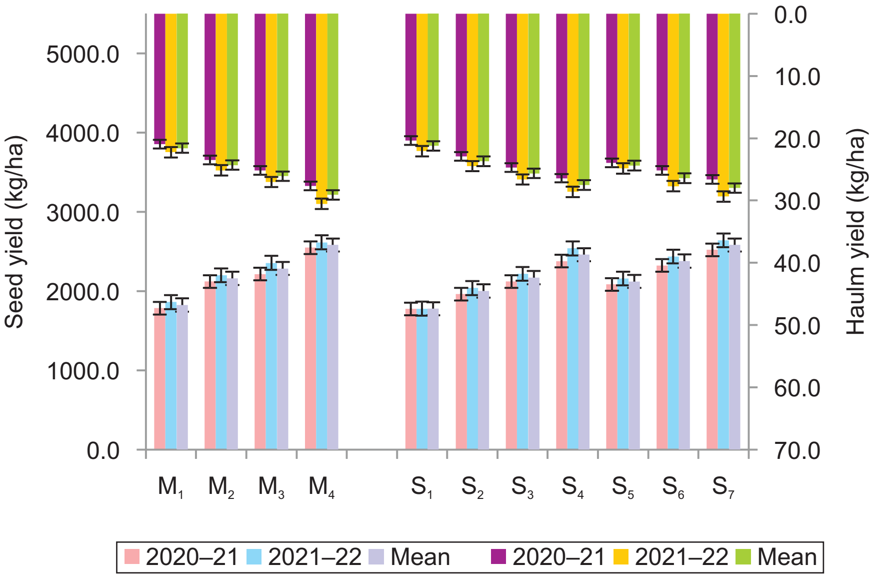

Fig 3 Seed and haulm yield of machine planted chickpea under varied seed rate and nutrient management.

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, conjunction 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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