Original Research Article

RESPONSE OF SUMMER FORAGE COWPEA (*Vigna unguiculata* L.) TO SPACING AND SEED RATE

ABSTRACT

A field experiment on "Response of summer forage cowpea (*Vigna unguiculata* L.) to spacing and seed rate" was carried out during summer 2022 on loamy sand soil of Agronomy Instructional Farm, C. P. College of Agriculture, SardarkrushinagarDantiwada Agricultural University, Sardarkrushinagar. The experiment was laid out in split plot design with four replications. The result revealed that Significantly the highest plant height was recorded under the line sowing at 30 cm. Higher numbers of branches per plant and leaf area per plant were observed under the line sowing at 45 cm. Cowpea sown at narrow row line sowing at 30 cm produced significantly the highest green forage and dry forage yield. The maximum net realization and benefit cost ratio were recoded under the line sowing at 30 cm. Seed rate of 50 kg/ha recorded significantly higher plant population and plant height. Higher number of branches per plant and leaf area per plant were recorded with seed rate of 30 kg/ha. Higher green forage and dry forage yield were recorded under seed rate of 50 kg/ha. The maximum net realization was accured with the seed rate of 50 kg/ha. The maximum benefit cost ratio was accured with the seed rate of 40 kg/ha.

Keywords:Cowpea, Spacing, Seed Rate, Forage, Yield

1. Introduction

Cowpea botanically known as *Vigna unguiculata* L. It is a quick growing legume fodder, capable of adapting to various agro-climatic and edaphic factors. It is known by the names of lobia or china pea or black-eyed pea or marble pea. Internationally, it is known as niebe, lobia, frigale or coupe. It is also commonly referred as "vegetable meat". It is an annual herb which may grow erect, bushy or climbing and trailing in manner but usually follows indeterminate growth habit under suitable environmental conditions. Cowpea fits well in warm weather and low rainfall areas and hence, mainly grown in poor soils of semi-arid regions of the lowland tropics and subtropics.In India, it is minor crop grown only in the states of Gujarat, Karnataka, Maharashtra, Rajasthan and Tamil Nadu. In Gujarat, it is mainly grown in Sabarkantha, Banaskatha, Mehsana, Patan, Ahmedabad, Kheda and Anand districts.

The world production of cowpea is 1.2 million tonnes grown on more than 3 million hectares yielding about 0.38 tonnes per hectare. In India cowpea is grown in about 0.25 million hectares for different purpose. In Gujarat current fodder availability is about 20 million tonnes as against the requirement of 49.2 million tonnes (Anonymous, 2006). Banaskantha (29,700 ha), Sabarkantha (29,300 ha) and Ahmedabad (28,700 ha) are the major fodder-growing districts of Gujarat. In Valsad, Dang, Dahod, Panchmahal, Vadodara, Porbandar and other districts, fodder crops areas were found to be less when compared to other district of the state. The total area under fodder crop in Gujarat district is 2,85,900 ha (Dutta *et al*., 2020).

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Spacing is major factor which affect the growth and yield of cowpea, because *Vigna unguiculata* is an annual plant with trailing stem and requires optimum space for vegetative growth. Similarly, it is well-known fact that two varieties of any crop cannot give similar performance in different agro-climatic regions due to genetic make-up and eco-physiological responses to different habitats. Also, the least availability of seeds are the major constraints in the forage production. It is more important because most of the forage crops have been tried substantially for vegetative purpose and they are shy seeders. Secondly, the forage crops are usually cut for fodder purpose before the seed setting. Thus, the opportunity of producing seeds is limited.The low availability of seeds are the major constraints in the forage production because most of the forage crops have been tried substantially for vegetative purpose and they are shy seeders. Secondly, the forage crops are usually cut for fodder purpose before the seed setting, so that the opportunity of producing seeds is limited. Beside this, the number of plants required per unit area is one of the prime considerations for higher biomass production which depends upon the nature of the crop, growth habit, branching and environment. This number of plants can neither be too small, so that all the production potential will not be utilized, nor can it be too large so that excessive plant competition will reduce the overall efficiency of the crop. Therefore, seed rate is one of the most important factors in achieving optimum level of plant density and ultimately forage quantity and quality with efficient use of the resources. Moreover, seed rates can affect crop yield, competitive ability with weeds, soil surface evaporation and light interception. Optimum seed rates in forage cowpea are greatly depends on genotypes, growing purposes and climatic conditions. In the plant population of early sown crop for compensating the biomass production could be the one of the options. This can be achieved by increasing the seed rate as it will increase the planting density which ultimately result in increased green fodder production per unit area. Among different agronomic practices/inputs, proper seed rate and row spacing plays a significant role in realizing higher yield potentiality.

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2. Material and Methods

A field experiment was conducted on Plot Number B-9 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, SardarkrushinagarDantiwada Agricultural University, Sardarkrushinagar during summer season of the year 2022. The data of soil analysis indicated that the soil of the experimental plot was loamy sand in nature, alluvial in origin, light brown in colour, well drained, fairly retentive of moisture and low in organic carbon and available nitrogen, while medium in available phosphorus and higher in available potassium. It is suitable for a variety of crops of arid and semi-arid origins.The experiment was laid out in a split plot design with four replications. There were nine treatments comprising in main plot threespacing (S_1: Broadcasting, S_2: Line sowing at 30 cm, S_3: Line sowing at 45 cm) and in sub plotthree levels of seed rates (E_1: 30 kg/ha), E_2: 40 kg/ha, E_3: 50 kg/ha).The crop was fertilized with 20:40:00 NPK kg/ha as per recommendation. Full dose of nitrogen and phosphorus was applied through urea and diammonium phosphate (DAP) before sowing as basal. The experimental field was prepared by tractor drawn implements. The field was cultivated by cultivator in both the directions and it was followed by harrowing and planking for levelling and preparation of fine seedbed. The graded and healthy seed of cowpea cv. EC 4216 were inoculated with Rhizobium culture @ 5 ml/kg seed before sowing.The seeds were sown manually at a depth of 5 cm in the spaced as per treatments where fertilizer applied and lightly covered with soil. During the crop season one interculturing and manually two hand weeding were carried out to keep the crop weed free.The biometric observations were recorded from five randomly selected tagged plants within each net plot for all parameters *viz*.,plant population,plant height (cm), Number of branches per plant,Leaf area per plant (cm^2),Leaf: stem ratio, Green forage yield (kg/ha), Dry forage yield (kg/ha), Crude protein content (%), Crude fibre content (%), net return and BCR.The data recorded for various parameters during the course of investigation were statistically analysed by a producer appropriate to the design of experiment as described by Panse and Sukhatme (1967). The significance of difference was tested by “F” test at 5 per cent level.

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3. Result and discussion

3.1Plant Population

The data presented in Table 1 revealed that the plant population at 20 DAS and harvest of summer forage cowpea did not differ significantly due to spacing. However, line sowing at 30 cm (S_2) at 20 DAS and harvest (3,19,680/ha and 3,17,402/ha),respectively showed higher plant population. Data presented in Table 1 indicated significant effect due to different seed rate on plant population at 20 DAS and harvest. Significantly higher plant population was recorded with higher seed rate 50 kg/ha (E_3) (3,16,865/ha and 3,12,393/ha) which remained statistically at par with 40 kg/ha (E_2) (3,01,669/ha and 2,99,074/ha), respectively.This might be due to the increased seed rate which ultimately increasing plant population. Similar results were also observed by Kumar and Seth (2004), Ayub *et al*. (2011) and Ahmad *et al*. (2016).

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3.2Plant height (cm)

Data presented in Table 1 indicated that significant effect due to different spacing on plant height. Among different spacing, line sowing at 30 cm (S_2) recorded significantly the highest plant height at harvest (90.26 cm).The plant height decreased with increased spacing from 30 cm to 45 cm and broadcasting. Plant height was remarkably accelerated at line sowing at 30 cm because, individual plant from the plots with narrow spacing did not get opportunity to proliferate laterally due to the less lateral space available and within plant less competition for resources. Hence, plants were competing to grow more in upward direction for the fulfilment of light requirement for photosynthesis. These results are close conformity with the finding of Nderi (2020), Raja *et al*. (2020), Majoka*et al*. (2021),Karadeniz and *et al*. (2022).Among different seed rate, 50 kg/ha (E_3) recorded significantly higher plant height at harvest (86.89 cm) though it was at par with 40 kg/ha seed rate (E_2) (85.06 cm).plant height decreased with decreased seed rate from 50 to 30 kg/ha. Plant height was remarkably accelerated at 50 kg/ha because, individual plant from the plots with narrow spacing did not get opportunity to proliferate laterally due to the less lateral space available and within plant less competition for resources. Hence, plants were competing to grow more in upward direction for the fulfilment of light requirement for photosynthesis. These results are close conformity with the finding of Tufail *et al.* (2019), Raja *et al.* (2020) and Rajab *et al*. (2022).

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3.3Number of branches per plant

Data presented in Table 1 indicated significant effect on the number of branches per plant due to different spacing. Among different spacing, line sowing at 45 cm (S_3) recorded significantly higher number of branches per plant at harvest (7.95) but, it was statically at par with broadcasting (S_1) (7.73).This might be due to plants grown with wider spacing got better opportunity of availing maximum space, light and nutrients which led to produce maximum branches per plant. The above finding is in complete agreement with earlier work done by Nderi (2020), Majoka*et al.* (2021) and Shukla and Singh (2021).Among different seed rate 30 kg/ha recorded significantly higher number of branches per plant at harvest (8.05) but, it was statically at par with seed rate 40 kg/ha (E_2). This might be due to plants grown with lower seed rate got better opportunity of availing maximum space, light and nutrients which led to produce maximum branches per plant. The above finding is in complete agreement with earlier work done by El Naim *et al*. (2012), Bhavya *et al*. (2016) and Alshikh 2019.

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3.4 Leaf area per plant (cm^2)

It is evident from the results furnished in Table 1 that leaf area per plant was significantly influenced due to different levels of spacing at harvest. Significantly higher leaf area per plant (3505 cm2) was observed under the treatment line sowing at 45 cm (S_3) but, it was statically at par with treatment broadcasting (S_1) (3357).The spacing had significant effects on growth, However, an increasing trend with closer spacing could be noticed. This may be due to the competition between the inter and intra plants for sun light, water, nutrients and space at closer spacing which encouraged self-thinning of branches and enhanced vertical growth rather than horizontal growth. The above finding is in complete agreement with earlier work done by Deka *et al.* (2015) and Makinta*et al*. (2020). Among different seed rate 30 kg/ha recorded significantly higher leaf area per plant (3478 cm^2) but, it was statically at par with seed rate 40 kg/ha (E^2). This might be due to plants grown with lower seed rate got better opportunity of availing maximum space, light and nutrients which led to produce maximum leaf area per plant. The above finding is in complete agreement with earlier work done by Bhavya (2012), Darwesh (2012) and Imran *et al*. (2015).

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3.5Leaf: stem ratio

The results presented in Table 1 indicated that leaf: stem ratio was differed significantly due to different spacing. The higher leaf: stem ratio was recorded with spacing of line sowing at 45 cm (0.83) than broadcasting (0.76) and line sowing at 30 cm (0.79). however, both were statistically at par. The leaf: stem ratio of cowpea did not affect significantly by various seed rate, but numerically higher value of leaf: stem was observed under higher seed rate 50 kg/ha (0.82) as compare to 30 and 40 kg/ha (0.77 and 0.79, respectively. The above finding is in complete agreement with earlier work done by Rajab *et al.* (2022).

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3.6 Green forage yield (kg/ha)

The data reported in Table 2 revealed that difference in green forage yield of cowpea was significantly influenced due to spacing. Significantly the highest green forage yield (28,525 kg/ha) was produced with narrow line spacing of 30 cm (S_2) while significantly lower green forage yield (24,452 kg/ha) was recorded under broadcasting treatment (S_1).The remarkable increase in green forage yield under narrow spacing (line sowing at 30 cm) was mainly due to accommodate more plants per unit area as well as taller plant which ultimately led to produce higher green forage yield per unit area. These results are in accordance with the finding of Kumar *et al*. (2020), Raja *et al*. (2020), Singh and Singh (2021) and Karadeniz *et al*. (2022).Significantly higher green forage yield (27,269 kg/ha) was produced with 50 kg/ha seed rate (E*3*) and it remained statistically at par with 40 kg/ha seed rate (E*2*) (26,443 kg/ha).The remarkable increase in green forage yield under higher seed rate was mainly due to accommodate more plants per unit area as well as taller plant which ultimately led to produce higher green forage per unit area. These results are in accordance with the finding of Bhavya *et al*. (2016), Tufail *et al*. (2019), Raja *et al*. (2020), Alzlzly and Al-Tahir (2021), Arif *et al*. (2022) and Rajab *et al.* (2022).

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3.7 Dry forage yield (kg/ha)

Data on dry forage yield presented in Table 2 showed that the effect of spacing was found significant. Significantly the highest dry forage yield (5,677 kg/ha) was produced with narrow line spacing of 30 cm (S_2). The remarkable increase in dry forage yield under narrow spacing (line sowing at 30 cm) was mainly due to accommodate more plants per unit area as well as taller plant which ultimately led to produce higher dry matter per unit area. These results are in accordance with the finding of Kumar *et al*. (2020), Makinta *et al.* (2020), Raja *et al*. (2020), Singh and Singh (2021), Shukla and Singh (2021) and Karadeniz *et al*. (2022).The data (Table 2) indicated that dry forage yield was significantly influenced due to different levels of seed rate. Dry forage yield was increased with increasing seed rate. Treatment E_3 (50 kg/ha) recorded significantly higher dry forage yield (5,468 kg/ha) but, it was at par with treatment E_2 (40 kg/ha) (5,300 kg/ha). This was ascribed due to maximum plant population and taller plants leading to increase dry forage yield. The similar results were reported by Bhavya *et al*. (2016), Tufail *et al* (2019), Raja *et al*. (2020), Alzlzly and Al-Tahir (2021), Arif *et al*. (2022) and Rajab *et al*. (2022).

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3.8 Crude protein content (%)

The data presented in Table 1 revealed that the crude protein content of summer forage cowpea did not differ significantly due to spacing. However, line sowing at 45 cm of the cowpea crop (S_3) gave numerically higher crude protein content (14.93%) than broadcasting and line sowing at 30 cm (14.80 and 14.75%), respectively. These results are in accordance with the finding of Midha *et al.* (2015), Amir Iqbal *et al*. (2018) and Shukla and Singh (2021). The data presented in Table 1 revealed that the crude protein content of summer forage cowpea did not differ significantly due to various seed rate. However, 30 kg/ha seed rate of the cowpea crop (E_1) gave numerically higher crude protein content (15.09%) than 40 and 50 kg/ha seed rate (14.79 and 14.60%), respectively. These results are in accordance with the finding of Darwesh (2012), Singh (2019) and Arif *et al*. (2022).

3.**9 Crude fibre content (%)**

The data presented in Table 1s revealed that the crude fibre content of summer forage cowpea did not differ significantly due to spacing. However, line sowing at 45 cm of the cowpea crop (S_3) gave numerically higher crude fibre content (26.69%) than broadcasting and line sowing at 30 cm (26.57 and 26.66%), respectively. These results are in accordance with the finding of Midha *et al*. (2015), Amir Iqbal et al. (2018) and Shukla and Singh (2021). The data presented in Table 1 revealed that the crude fibre content of summer forage cowpea did not differ significantly due to seed rate. However, at 30 kg/ha seed rate of the cowpea crop (E_1) gave numerically higher crude protein content (26.99%) than 40 and 50 kg/ha (26.48 and 26.45%), respectively. These results are in accordance with the finding of Bhavya (2012), Singh (2019) and Arif *et al*. (2022).

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3.10 Economics

The results presented in Table 2 indicated that the maximum gross realization (1,42,625 ₹/ha), net realization (1,08,137 ₹/ha) and BCR (4.14) were accrued with the spacing of line sowing at 30 cm (S2).It was such due to lower plant population which ultimately gave lower yield and thus lower gross

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realization, net realization and BCR ratio. These findings are in close conformity with those reported by Aamir Iqbal et al. (2018) and Kumar et al. (2020).50 kg/ha seed rate (E3) gave the highest gross realization (1,36,344 ₹/ha) and net realization (1,00,581 ₹/ha) while highest BCR (3.87) was found in 40 kg/ha seed rate (E2). The higher net realization be due to higher green forage yield recorded by 50 kg/ha seed rate (Table 1). These findings are in conformity with those reported by Amarnath (2001), Yusufali et al. (2007), Bhavya (2012) and Singh (2019).

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4. Conclusion

Based on the results of one year experimentation, it is concluded that forage cowpea (cv. EC 4216) should be sown at 30 cm row spacing and seed rate of 40 kg/ha for securing higher green forage yield and net realization on loamy sand soil.

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Table 1: Growth parameters, yield attributesand quality of summer forage cowpea as influenced by spacing and seed rate

Treatment	Plant population per ha		Plant height (cm)	Number of branches per plant	Leaf area per plant (cm^2)	Leaf: stem ratio	Crude protein content (%)	Crude fibre content (%)
	At 20 DAS	At harvest						
Spacing (S)								
S_1 : Broadcasting	284324	281039	78.73	7.73	3357	0.76	14.80	26.57
S_2 : Line sowing at 30 cm	319680	317402	90.26	7.10	3185	0.79	14.75	26.66
S_3: Line sowing at 45 cm	291036	285867	82.52	7.95	3505	0.83	14.93	26.69
S.Em.±	9088	9448	2.06	0.19	71	0.02	0.21	0.47
C.D. at 5%	NS	NS	7.12	0.65	244	NS	NS	NS
C.V. %	10.55	11.10	8.50	8.61	7.29	10.75	4.88	6.12
Seed rate (E)								
E_1 : 30 kg/ha	276506	272842	79.55	8.05	3478	0.77	15.09	26.99
E_2 : 40 kg/ha	301669	299074	85.06	7.54	3348	0.79	14.79	26.48
E_3 : 50 kg/ha	316865	312393	86.89	7.19	3221	0.82	14.60	26.45
S.Em.±	8637	8418	1.83	0.18	65	0.02	0.19	0.45
C.D. (P=0.05)	25661	25010	5.44	0.55	192	NS	NS	NS
Interaction (S × E)								
S.Em.±	14959	14580	3.17	0.32	112	0.04	0.32	0.78
C.D. at 5%	NS	NS	NS	NS	333	NS	NS	NS
C.V. %	10.03	9.89	7.57	8.37	6.70	9.21	4.36	5.86

Table 2:Yield and economics of summer forage cowpea as influenced by spacing and seed rate

Treatment	Green forage Yield (kg/ha)	Dry forage yield (kg/ha)	Cost ofcultivation(₹/ha)	Grossrealization(₹/ha)	Netrealization(₹/ha)	BCR
Spacing (S)						
S_1 : Broadcasting	24452	4921	34148	122261	88113	3.58
S_2 : Line sowing at 30 cm	28525	5677	34488	142625	108137	4.14
S_3: Line sowing at 45 cm	25464	5117	33808	127322	93514	3.77
S.Em.±	789	155	-	-	-	-
C.D. at 5%	2731	536	-	-	-	-
C.V. %	10.45	10.25	-	-	-	-
Seed rate (E)						
E_1 : 30 kg/ha	24730	4948	32533	123649	91116	3.80
E_2 : 40 kg/ha	26443	5300	34148	132215	98067	3.87
E_3 : 50 kg/ha	27269	5468	35763	136344	100581	3.81
S.Em.±	553	112	-	-	-	-
C.D. (P=0.05)	1643	333	-	-	-	-
Interaction (S × E)						
S.Em.±	958	194	-	-	-	-
C.D. at 5%	NS	NS	-	-	-	-
C.V. %	7.33	7. 41	-	-	-	-

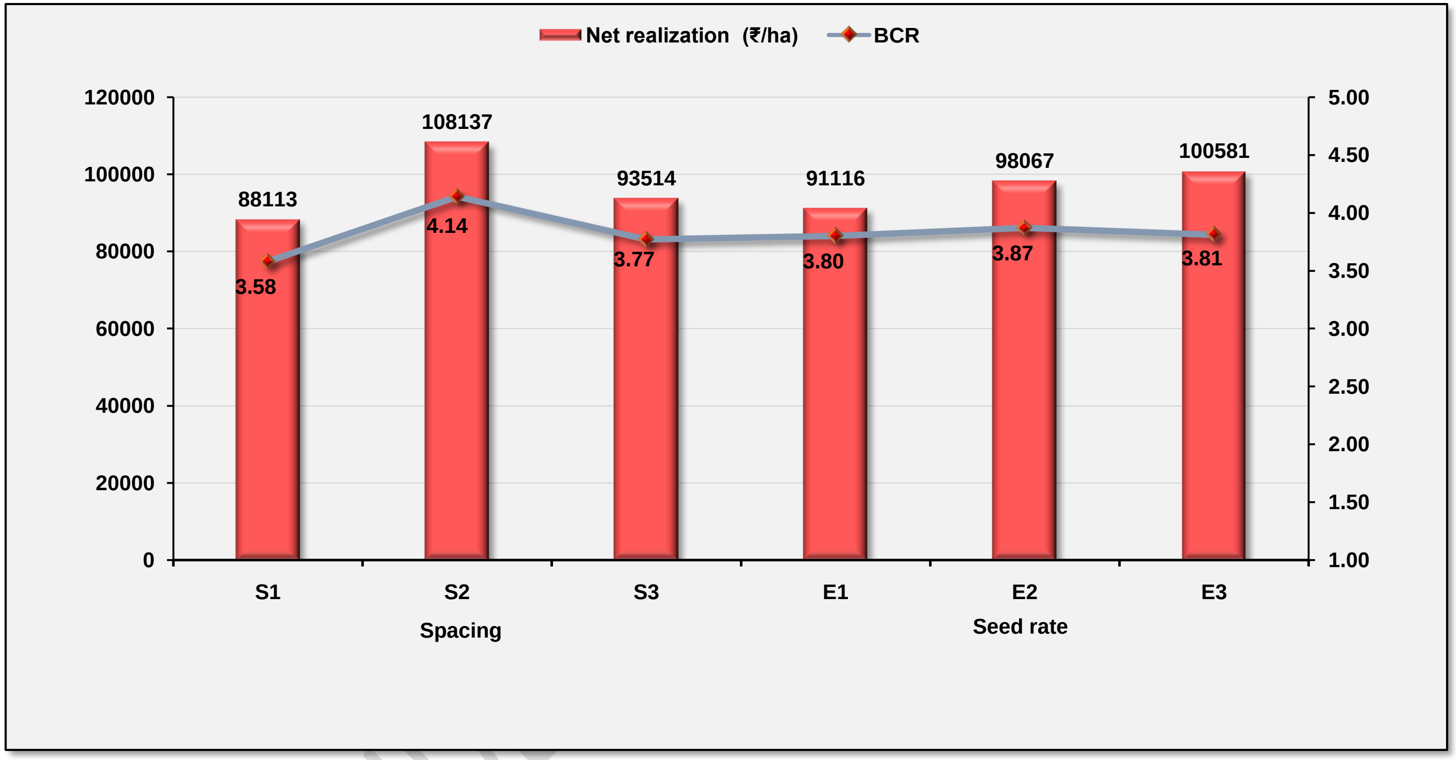

Figure 1: Economics of summer forage cowpea as influenced by spacing and seed rate