A field experiment was carried out during summer 2015 at the Pulses and Castor Research station, Navsari Agricultural University, Navsari to evaluate land configuration and fertilizer management practices on growth and yield parameters, yield, quality and economics of cowpea (Vigna unguiculata L.) cultivation. Experimental plot was clayey soil having a pH 7.95 and poor in available nitrogen (210 kg/ha), medium in available phosphorus (35.15 kg/ha) and considerably rich in available potash (340.50 kg/ha). To study three methods of land configuration viz., (flat bed, ridge and furrow and raised bed) and five fertilizer management practices (FYM 4 t/ha, bio-compost 2 t/ha, FYM 2 t/ha + 50% RDF, bio-compost 1t/ha + 50% RDF and 100% RDF) were evaluated in split plot design with three replications. The raised bed method of planting was recorded significantly higher growth and yield attributes, seed yield (921 kg ha⁻¹), stover yield (1992 kg ha⁻¹), net returns (₹ 36,692 ha⁻¹) and BCR ratio (3.12) than flatbed method of sowing. Application of 100% recommended dose of fertilizer gave significantly higher value for all growth and yield attributes, seed yield, stover yield, net returns and BCR ration than other treatments.

**Keywords**
Cowpea, Economics, Fertilizer management, Growth, Land configuration, Quality content, Vigna unguiculata L., Yield and yield attributes

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**Abstract**

A field experiment was carried out during summer 2015 at the Pulses and Castor Research station, Navsari Agricultural University, Navsari to evaluate land configuration and fertilizer management practices on growth and yield parameters, yield, quality and economics of cowpea (Vigna unguiculata L.) cultivation. Experimental plot was clayey soil having a pH 7.95 and poor in available nitrogen (210 kg/ha), medium in available phosphorus (35.15 kg/ha) and considerably rich in available potash (340.50 kg/ha). To study three methods of land configuration viz., (flat bed, ridge and furrow and raised bed) and five fertilizer management practices (FYM 4 t/ha, bio-compost 2 t/ha, FYM 2 t/ha + 50% RDF, bio-compost 1t/ha + 50% RDF and 100% RDF) were evaluated in split plot design with three replications. The raised bed method of planting was recorded significantly higher growth and yield attributes, seed yield (921 kg ha⁻¹), stover yield (1992 kg ha⁻¹), net returns (₹ 36,692 ha⁻¹) and BCR ratio (3.12) than flatbed method of sowing. Application of 100% recommended dose of fertilizer gave significantly higher value for all growth and yield attributes, seed yield, stover yield, net returns and BCR ration than other treatments.
Cultivation of cowpea in summer season is increasing in Gujarat, especially in South Gujarat where perennial water supply from Ukai-Kakrapara project is available to meet the demand of irrigation. But, pulses crop are very sensitive to water logging and salt injury. Poor quality irrigation water is the important factors for low productivity of summer season crop in south Gujarat. The land configuration can play an important role for easy and uniform germination as well as growth and development of plants. It is particular useful in areas having poor quality of irrigation water because it helps to avoid direct contact of young plants with saline irrigation water. Raised bed method of sowing has been found helpful to minimize the effect of temporary water logging and salt injury of plants (Dhimmar, 2003; Akbar et al., 2007).

Fertilizers play vital role in maintaining/improving soil fertility status as the readily available nutrient to plants. Inadequate or excess supply of any plant nutrient limit may the crop production. Among the plant nutrients, nitrogen and phosphorus are the most important and expensive nutrient and it has marked effect on the plant growth in pulses crops. Cowpea being a leguminous crop, utilize atmospheric nitrogen through symbiotic nitrogen fixation to meet a major parts of its nitrogen requirement. The formation of root nodule and nitrogen fixation starts at about 15-20 days after sowing. Thus, a starter does of nitrogen may be required for boosting the initial growth stage. Phosphorus has been found to be limited factor in legume production. It promotes the flowering and aids in setting of pods. It plays a vital role in nodulation and improves the protein content in legume crops. The present study was therefore, undertaken to evaluate the effect of land configuration and fertilizer management practices on productivity profitability of summer season cowpea under south Gujarat condition.

**Materials and Methods**

The experiment was conducted at farm of Pulses and Castor Research Station, Navsari Agricultural University, Navsari (Gujarat) to study the response of summer cowpea (*Vigna unguiculata* L.) to land configuration and fertilizer management practices under south Gujarat condition during summer season of the year 2015. The experimental plot was geographically located at 20º 57’ N latitude and 72º 54’ E longitude at an altitude of 10 meters above the mean sea level. Navsari is coming under south Gujarat heavy rainfall zone. The climate of this region is characterized by fairly hot summer, moderately cold winter and humid and warm monsoon with heavy rainfall. The soil of experimental plot was clayey in texture with 7.95 pH, low in available nitrogen (210 kg/ha), medium in available phosphorus (35.15 kg/ha), fairly rich in available potassium (340.50 kg/ha) as well as slightly alkaline in reaction. There were fifteen treatment combinations consisting of three methods of land configuration viz., (flat bed, ridge & furrow and raised bed) and five fertilizer management practices (FYM 4 t/ha, bio-compost 2 t/ha, FYM 2 t/ha + 50% RDF, bio-compost 1t/ha + 50% RDF and 100% RDF). These were evaluated in split plot design, where method of land configuration sowing were allocated to main plots, while fertilizer management practices were assigned to sub-plots and replicated thrice. The raised beds were prepared by using tractor drawn raised bed maker and ridge and furrow were prepared by manually. Gujarat cowpea 4 (GC 4) variety was sown on 24th February, 2015 at a row spacing of 45 X 10 cm (Normal) and 30 X 30 X 45 X 10 cm (pair row on raised bed) using seed rate of 25 kg/ha and fertilized with 20-40-00 N-P2O5-K2O/ha. The experimental plot was manured as per treatments with organic fertilizer and chemical fertilizer before sowing of crop. The require quantity of FYM
and biocompost as well as chemical fertilizer in the form of urea and DAP (Diammonium phosphate) manually applied in opened furrows as per treatment before sowing. Gap filling and thinning were done when necessary and harvesting was done when crop was fully matured.

Results and Discussion

Growth attributes

Cowpea plants exhibited significant response to various land configurations and fertilizer management practices on growth attributes. The periodical observation viz., plant height, dry matter accumulation and number of nodules per plant (Table 1) at 60 DAS and harvest stage showed significant difference due to land configuration methods except at number of branches per plant and day to 50% flowering.

The maximum values for plant height (43.09, 45.37 cm), dry matter accumulation per plant (25.17, 36.33 g) and number of nodules per plant (53.57, 47.60) at 60 DAS and at harvest were recorded under raised bed method of sowing than flatbed method of sowing. This might be due to maintain of proper air moisture regimes under raised bed method of sowing which improved supply of required moisture, available nutrients, soil aeration and better soil environment ultimately resulted in better growth and development of crop.

Sowing on raised bed was particularly helpful as experimental soil content was highly clay (66.40%) is susceptible to waterlogging problem for over irrigation. The findings are in complete agreement with earlier work done by Shete et al., (2010), Jat et al., (2012) and Shinde (2012).

Application of 100% recommended dose of fertilizers (RDF) resulted in significantly higher plant height, dry matter accumulation and number of nodules per plant at 60 day after sowing and harvest stage but, it was statistically Sam bar with application of 50% RDF + FYM 2 t/ha over other treatments.

Improvement in growth attributes due to application of inorganic fertilizer enhanced the availability of nutrients especially nitrogen which is mainly responsible for vegetative growth and phosphorus played important role in root development and increased nodule activity in plant. These results confirm the findings of Abayomi et al., (2008), Choudhary and Yadav (2011) and Khandelwal et al., (2013).

Yield attributes and yield

Land configuration methods did not influence significantly for number of seeds per pod and 100 seed weight (Table 2). While number of pods per plant and yield was influenced significantly.

Number of pods per plant was significantly higher under raised bed method of sowing as compared to flatbed method of sowing. The better performance of cowpea crop observed in term of plant height, dry matter accumulation per plant and number of root nodules per plant obtained under raised bed method of sowing which ultimately reflected in higher number of pods per plant of summer cowpea.

Further, higher number of pods per plant under raised bed method of sowing resulted in significantly higher seed yield (921 kg ha⁻¹). The increased in seed yield under raised bed was 21.02 % over flatbed methods of sowing. Similar trend was also observed for stover yield (1992 kg ha⁻¹) of cowpea because of higher dry matter accumulation per plant under raised bed method of sowing.
### Table 1: Effect of land configuration and fertilizer management practices on growth and growth attributes of summer cowpea (*Vigna unguiculata* L.) under south Gujarat condition

| Treatments | Plant height (cm) | Number of nodules per plant | Dry matter accumulation per plant (g) | Number of branches per plant | Days to 50% flowering |
|------------|-------------------|-----------------------------|---------------------------------------|-----------------------------|-----------------------|
|            | 60 DAS At harvest | 60 DAS At harvest | 60 DAS At harvest | 60 DAS At harvest |                      |
| (A) Land configuration |                      |                       |                     |                      |                      |
| L₁: Flat bed | 37.90 | 39.28 | 45.50 | 39.71 | 22.39 | 30.27 | 3.61 | 4.05 | 44.47 |
| L₂: Ridge and furrow | 41.02 | 43.13 | 50.51 | 45.54 | 24.60 | 34.55 | 3.80 | 4.24 | 44.60 |
| L₃: Raised bed | 43.09 | 45.37 | 53.57 | 47.60 | 25.17 | 36.33 | 3.82 | 4.32 | 45.13 |
| S. Em. ± | 1.12 | 1.22 | 1.70 | 1.17 | 0.55 | 0.98 | 0.07 | 0.10 | 0.71 |
| C. D. (P=0.05) | 4.42 | 4.79 | 6.67 | 4.61 | 2.17 | 3.86 | NS | NS | NS |
| C. V. % | 10.71 | 11.09 | 13.20 | 10.27 | 8.89 | 11.30 | 7.37 | 9.62 | 6.18 |
| (B) Fertilizer management |                      |                       |                     |                      |                      |
| F₁: FYM (4 t ha⁻¹) | 39.69 | 41.23 | 46.44 | 41.52 | 22.76 | 32.23 | 3.69 | 4.16 | 44.22 |
| F₂: BC (2 t ha⁻¹) | 36.72 | 38.57 | 44.22 | 40.10 | 21.79 | 29.81 | 3.61 | 4.04 | 43.56 |
| F₃: 50 % RDF + FYM (2 t ha⁻¹) | 41.96 | 43.70 | 53.58 | 47.55 | 25.51 | 35.19 | 3.80 | 4.24 | 45.00 |
| F₄: 50 % RDF + BC (1 t ha⁻¹) | 40.61 | 42.59 | 49.71 | 43.44 | 24.11 | 33.66 | 3.73 | 4.20 | 44.44 |
| F₅: 100 % RDF | 44.38 | 46.88 | 55.36 | 48.82 | 26.09 | 37.68 | 3.89 | 4.38 | 46.44 |
| S. Em. ± | 1.22 | 1.36 | 1.85 | 1.40 | 0.65 | 0.97 | 0.08 | 0.12 | 0.70 |
| C. D. (P=0.05) | 4.42 | 3.96 | 5.40 | 4.08 | 1.90 | 2.83 | NS | NS | NS |
| C. V. % | 9.01 | 9.54 | 11.13 | 9.48 | 8.12 | 8.63 | 6.26 | 8.63 | 4.73 |
Table 2: Effect of land configuration and fertilizer management practices on yield, yield attributes and quality of summer cowpea (Vigna unguiculata L.) under south Gujarat condition

| Treatments | Number of pods per plant | Number of seeds per pod | 100 seeds weight (g) | Seed yield (kg ha⁻¹) | Stover yield (kg ha⁻¹) | Harvest index (%) | Protein content (%) | Protein yield (kg ha⁻¹) |
|------------|--------------------------|------------------------|---------------------|---------------------|------------------------|-------------------|--------------------|------------------------|
| (A) Land configuration | | | | | | | | |
| L₁: Flat bed | 9.24 | 10.11 | 10.60 | 761 | 1704 | 30.80 | 19.60 | 149.67 |
| L₂: Ridge and furrow | 10.35 | 10.33 | 11.05 | 853 | 1871 | 31.24 | 20.08 | 171.42 |
| L₃: Raised bed | 11.04 | 10.49 | 11.18 | 921 | 1992 | 31.51 | 20.29 | 187.14 |
| S. Em. ± | 0.24 | 0.14 | 0.20 | 24.7 | 43.3 | 0.32 | 0.32 | 7.21 |
| C. D. (P=0.05) | 0.93 | NS | 97 | NS | NS | 28.30 |
| C. V. % | 9.02 | 5.13 | 7.18 | 11.31 | 9.05 | 4.01 | 6.14 | 16.48 |
| (B) Fertilizer management | | | | | | | | |
| F₁: FYM (4 t ha⁻¹) | 9.60 | 9.96 | 10.82 | 791 | 1779 | 30.74 | 19.80 | 157.07 |
| F₂: BC (2 t ha⁻¹) | 9.24 | 9.57 | 10.57 | 759 | 1713 | 30.62 | 19.69 | 149.79 |
| F₃: 50 % RDF + FYM (2 t ha⁻¹) | 10.60 | 10.60 | 11.06 | 882 | 1925 | 31.38 | 20.19 | 178.60 |
| F₄: 50 % RDF + BC (1 t ha⁻¹) | 10.33 | 10.39 | 10.95 | 846 | 1854 | 31.29 | 20.03 | 169.09 |
| F₅: 100 % RDF | 11.27 | 11.04 | 11.32 | 948 | 2007 | 31.88 | 20.23 | 192.49 |
| S. Em. ± | 0.28 | 0.17 | 0.25 | 29.5 | 43.6 | 0.36 | 0.34 | 7.41 |
| C. D. (P=0.05) | 0.81 | 0.48 | 0.48 | NS | NS | 21.64 |
| C. V. % | 8.19 | 4.82 | 6.89 | 10.49 | 7.05 | 3.48 | 5.12 | 13.13 |

Table 3: Effect of land configuration and fertilizer management practices on economics of summer cowpea (Vigna unguiculata L.) under south Gujarat condition

| Treatments | Seed yield (kg ha⁻¹) | Stover yield (kg ha⁻¹) | Gross realization (₹ ha⁻¹) | Cost of cultivation (₹ ha⁻¹) | Cost of cultivation (₹ ha⁻¹) | BCR |
|------------|----------------------|------------------------|---------------------------|-----------------------------|-----------------------------|-----|
| (A) Land configuration | | | | | | |
| L₁: Flat bed | 761 | 1704 | 44866 | 15526 | 0 | 15526 | 29340 | 2.89 |
| L₂: Ridge and furrow | 853 | 1871 | 50134 | 15526 | 1200 | 16726 | 33408 | 3.00 |
| L₃: Raised bed | 921 | 1992 | 54018 | 15526 | 7073 | 22599 | 36692 | 3.12 |
| (B) Fertilizer management | | | | | | |
| F₁: FYM (4 t ha⁻¹) | 791 | 1779 | 46666 | 15526 | 12000 | 27526 | 19140 | 1.70 |
| F₂: BC (2 t ha⁻¹) | 759 | 1713 | 44802 | 15526 | 11000 | 26526 | 18276 | 1.69 |
| F₃: 50 % RDF + FYM (2 t ha⁻¹) | 882 | 1925 | 51800 | 15526 | 7073 | 22599 | 29201 | 2.29 |
| F₄: 50 % RDF + BC (1 t ha⁻¹) | 846 | 1854 | 49716 | 15526 | 6573 | 22099 | 25617 | 2.25 |
| F₅: 100 % RDF | 948 | 2007 | 55428 | 15526 | 2147 | 17673 | 37755 | 3.14 |
This might due to the cumulative effect exerted from improvement in soil environment, aeration, root development, optimum moisture-air equilibrium throughout the crop growth period besides easily supply of available nutrients to the crop resulted in better growth and development ultimately reflected in higher seed and stover yields. The results are in accordance with finding of Pramanik et al., (2009), Shete et al., (2010), Jat et al., (2012) and Shinde (2012). Application of 100% RDF significantly improved yield attributes and yield over other treatments. Significantly higher values for number of pods per plant, number of seeds per pod were recorded under treatment receiving 100 % RDF than other treatments. The higher value of yield attributes with application of 100% RDF were largely attributed to better growth of plant in term of plant height, dry matter accumulation per plant and number of root nodules per plant which resulted in higher production of photosynthates were utilized by the plant for development of sink under adequate supply of nutrients through recommended dose of fertilizers gave higher number of pods per plant and number of seeds per pod. The present findings are in agreement with those reported by Abayomi et al., (2008) and Das et al., (2011). Similarly, seed yield and stover yield were also recorded significantly higher with application of 100% RDF than other treatments. Application of 100% RDF gave 24.90% and 17.16% higher seed and stover yield than application of biocompost 2 t/ha, respectively. The higher yield under these treatments might be due to cumulative effect of better yield attributes (number of pods per plant and number of seeds per pod) and higher nutrient uptake by cowpea. The positive response in terms of seed and stover yield of cowpea to inorganic fertilizer have also reported by Channabasappa et al., (2004), Patel et al., (2010), Choudhary and Yadav (2011), Choudhary et al., (2013), and Verma et al., (2014). In case of harvest index (Table 2), there is no significant difference in land configurations and fertilizer management practices.

**Quality control**

Different land configuration methods and fertilizer management practices did not exert any significant effect on protein content (Table 2) whereas, it had significant effect on protein yield (Table 2). Significantly higher protein yield (187.14kg ha⁻¹) was noted under raised bed method of sowing as compared to flatbed method of sowing. This increase in protein yield was mainly due to higher seed yield under raised bed method of sowing. The result was confirmed by Jat et al., (2012) and Shinde (2012). The results (Table 2) revealed that various fertilizer management practices had significant effect on protein yield. The higher protein yield (192.49 kg ha⁻¹) was noted with treatment 100 % RDF than other treatments. The higher protein yield with these treatments might be due to higher seed yield. Similar findings were also reported by Dekhane et al., (2011) and Verma et al., (2014).

**Economics**

Economics is the major consideration for the farmers while taking a decision regarding the adoption of new technology. Raised bed method of sowing recorded higher net returns (₹ 36,692 ha⁻¹) and benefit cost ratio (3.12) over flatbed method of sowing (Table 3). This was due to higher yield of seed and stover under raised bed method of sowing. These results are conformity with those reported by Pramanik et al., (2009) and Jat et al., (2012). Application of 100% RDF recorded higher net returns (₹ 37755 ha⁻¹) and benefit cost ratio (3.14) as compared to other treatments. The higher net returns and BCR under these treatments was mainly due to higher yields.
and low cost of cultivation. Similar results were also reported by Choudhary et al., (2013), Khandelwal et al., (2013) and Verma et al., (2014).

It can be concluded that summer cowpea var. GC 4 should be sown on raised bed method (90 cm width X 45 cm wide and 30 cm deep furrow) and fertilized with 100% recommended dose of fertilizer (20:40:00 kg N:P\textsubscript{2}O\textsubscript{5}:K\textsubscript{2}O ha\textsuperscript{-1}) under South Gujarat condition for obtaining higher yield and monetary returns.

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