Growth, Yield and Oil quality of Mustard in Chickpea (*Cicer arietinum*) and Mustard (*Brassica juncea* L.) Intercropping System under Different Row Ratio in Northern Transition Zone of Karnataka

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**ABSTRACT**

A field experiment was conducted during rabi season of 2017 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, to study different row ratio of chickpea and mustard on growth, yield and quality of mustard. The experiment was conducted in randomized block design with two sole crops of chickpea and mustard including eight different row ratio of chickpea + mustard (2:1, 3:1, 3:3, 4:2, 4:4, 5:1, 6:2 and 8:2). Results indicate that, sole mustard recorded higher growth parameters viz. plant height, leaf area, number of branches primary and secondary per plant, dry matter and higher seed, straw yield and harvest index. Among intercropping, higher growth attributes were found in 5:1 row ratio. Significantly higher seed (1128 kg ha⁻¹), straw yield (2294 kg ha⁻¹) and harvest index (27.62%) was found in 4:4 ratio, followed by 3:3 row ratio. Higher oil content (35.16%) and oil yield (606 kg ha⁻¹) was recorded in sole mustard.

**Key words:** Chickpea, Intercropping, Mustard, Row ratio, Quality.

**INTRODUCTION**

Chickpea is the most important winter pulse crop cultivated in almost all parts of the country including Asia, Africa, Europe, North America and South America continent. In India it is grown both under assured irrigation and residual soil moisture conditions. In India, it is grown over an area of 82.51 lakh hectares with production of 73.32 lakh tonnes with the productivity 889 kg per hectare (Anonymous 2017a). In Karnataka, it is grown in an area of 9.39 lakh hectares with production of 6.74 lakh tonnes and productivity of 718 kg per hectare. In India, mustard is grown over an area of 57.91 lakh hectares with a production of 62.8 lakh tonnes and productivity of 1,083 kg per hectare (Anonymous 2017b). In Karnataka, it is grown in an area of 0.02 lakh hectares with a production of 0.01 lakh tonnes and productivity 500 kg per hectare. Its cultivation is also being extended to non-traditional areas of Southern States like Karnataka, Tamil Nadu and Andhra Pradesh.

India has achieved great strides in production of food grains; the low level of production of oilseeds is a matter of great concern. The increasing gap between demand and supply of vegetable oils in the country can be bridged only by increasing their production per unit area per unit time due to non-availability of land for further expansion of area under oilseeds. In India, over 65 per cent of the total vegetable oil produced is derived from soybean and rapeseed-mustard. Mustard stands second in edible oil production after soybean in India and most important oilseed in winter season. There is very little chance for horizontal growth of the crop. Thus, production of mustard can be increased by vertical growth of the crop through intercropping with other crops. Nowadays, mustard has been found successfully intercropped mainly with different crops viz. chickpea, lentil, sugarcane, potato, wheat, etc. under various agro climatic zones of the country.

Intercropping is a crop management system involving the growing of two or more economic dissimilar crop species or varieties in distinct row combinations simultaneously on the same piece of land (Ahlawat and Sharma, 2002). Conceptually, intercropping system helps for risk avoidance from epidemic of insect-pest and disease and overcome the effect of adverse environmental conditions in agro-climatologically unstable regions along with better utilization of solar radiation and inputs like fertilizer and water compared to crops in sole system. It means intercropping...
Intercropping of chickpea and mustard in spatial row arrangements is one of the most important aspects of intercropping systems. The yield advantage of mixed crops grows not only with the proper choice of the component crops but also on spatial arrangement of plants. The present study was conducted during the rabi season of 2017-18 at Main Agricultural Research Station, UAS, Dharwad. The experimental site having black clay soil (Vertisols). The complex soil sample was composed from investigational site before sowing of crops and same was analysed for physical and chemical properties. Soil was clay with pH of 7.3 and electrical conductivity of 0.32 dS m⁻¹. The soil was medium in organic carbon (0.53 %), low in available potassium (320 kg ha⁻¹), medium in available phosphorus (30 kg ha⁻¹) and medium in available potassium (320 kg ha⁻¹) (Table 1). The average rainfall of dharwad area was 722.7 mm but during 2017 a rainfall of 582.8 mm was received which was 45.2 per cent less than normal rainfall of the station. A rainfall of 197.6 mm was received in the month of September which helped for land preparation and soil moisture recharge. The rainfall and soil moisture circumstances were most favourable during rabi season with rainfall of 197.6, 72.6, 16.2 and 0.4 mm received during September, October, November and December months respectively and the total rainfall during cropping period (September, October, November and December) was 286.9 mm. It helped for improved growth and maturity of chickpea and mustard. The experiment comprising 10 treatments was conducted in randomized block design replicated thrice, had two sole crops (chickpea, Indian mustard) and 8...
combinations of chickpea intercropping with mustard in 2:1, 3:1, 3:3, 4:2, 4:4, 5:1, 6:2 and 8:2 row proportions. The crops were sown on 19 October, 2017 and harvested on 2nd January, 2018. A row spacing of 30 cm was adopted for sowing of both the crops with a plant-to-plant spacing of 10 cm. A seed rate of 9 kg ha⁻¹ was followed in mustard. A common fertilizer dose of 25:50:0 (N: P₂O₅: K₂O kg ha⁻¹) to chickpea and 60:50:0 (N: P₂O₅:K₂O kg ha⁻¹) to mustard. Fertilizer was applied based on population in each treatment at the time of sowing. The cultivars used in the study were Jaki-9218 (chickpea), 'NRCHB-101 (Indian mustard). Mustard was sprayed with Lambda-cyhalothrin @ 2 ml l⁻¹ of water to manage sawfly and aphids at early stage of the mustard and ridomyl gold was sprayed @ 2 g l⁻¹ of water after 50 days to manage white rust in mustard.

**Plant sampling and statistical analysis**

The five randomly selected plants from net plot area and were used to record different growth attributes at different growth stages (30, 60 DAS, 75 DAS and at harvest). The samples were dried at 70°C to attain constant dry weight. Dry mass was recorded independently at every phase of crop growth and total dry matter production per plant was calculated and was expressed in grams per plant (g plant⁻¹). With respect to yield data firstly all the border plants were cut close to ground level and kept separately and then plants from net plot area were cut at the base close to ground level. The plants were heaped and left for drying. The dried plants were threshed with bamboo stick to separate the seeds from siliquae from mustard. After threshing the seeds were winnowed, cleaned and seed weight net plot was recorded. The stalk yield per net plot was recorded separately and used to work out yield per hectare. Oil content was determined by NMR method. The data obtained from various characters under study were analysed by the method of analysis of variance as described by (Gomez and Gomez, 1984).

**RESULTS AND DISCUSSION**

**Growth parameters**

**Plant height**

Plant height was found higher with sole mustard at 30, 60 DAS and at harvest (Table 3). At 30 DAS, no significant difference was observed but numerically higher plant height was found with sole mustard (38.3 cm). The higher plant height with sole mustard was due to good vegetative growth of the mustard and there was no competition from intercrop to mustard. At 60 DAS, sole mustard recorded higher plant height (157.3 cm) and on par on par with 2:1 (145.9), 3:1 (151.3), 6:2(154.1) among intercropping treatments, 5:1 row ratio of chickpea + mustard recorded higher plant height (154.1 cm) which was on par with 2:1(145.9), 3:1 (151.3), 6:2(154.1) and 8:2 (141.1), whereas significantly lower plant height was observed with 4:4 row ratio of chickpea + mustard (133.6 cm). At harvest also, 5:1 row ratio of chickpea + mustard recorded higher plant height (159 cm) which was on par in 2:1 (145.9), 3:1 (151.3), 6:2(154.1) and 8:2 (141.1). Significantly lower plant height observed in 4:4 row ratio of chickpea + mustard (136.1 cm).

**Table 1: Plant populations of different treatments.**

| Treatment                      | Chickpea population (%) | Mustard population (%) |
|--------------------------------|-------------------------|------------------------|
| T<sub>1</sub> Chickpea + mustard (2:1) | 66.6                    | 33.3                   |
| T<sub>2</sub> Chickpea + mustard (3:1) | 75                      | 25                     |
| T<sub>3</sub> Chickpea + mustard (3:3) | 50                      | 50                     |
| T<sub>4</sub> Chickpea + mustard (4:2) | 66.6                    | 33.3                   |
| T<sub>5</sub> Chickpea + mustard (4:4) | 50                      | 50                     |
| T<sub>6</sub> Chickpea + mustard (5:1) | 83.3                    | 16.7                   |
| T<sub>7</sub> Chickpea + mustard (6:2) | 75                      | 25                     |
| T<sub>8</sub> Chickpea + mustard (8:2) | 80                      | 20                     |
| T<sub>9</sub> Sole chickpea          | 100                     | -                      |
| T<sub>10</sub> Sole mustard         | -                       | 100                    |

**Table 2: Soil physical and chemical properties of the experimental site.**

| Sl. no. | Particulars                | Values | Method                                      |
|---------|----------------------------|--------|---------------------------------------------|
| I       | Physical properties        |        |                                             |
| A       | Coarse sand (%)            | 7      | International Pipette Method (Piper, 1966)  |
| B       | Fine sand (%)              | 12.21  |                                             |
| C       | Silt (%)                   | 27.83  |                                             |
| D       | Clay (%)                   | 52.95  |                                             |
| E       | Textural class             | Clay   |                                             |
| II      | Chemical properties        |        |                                             |
| 1.      | pH (1:2.5 soil : water extract) | 7.3    | Conductivity Bridge (Piper, 1966)          |
| 2.      | EC (1:2.5 soil : water extract) | 0.32   | Walkley and Black Wet Oxidation Method (Jackson, 1967) |
| 3.      | Organic carbon (%)         | 0.53   |                                             |
| 4.      | Available nitrogen (kg ha⁻¹) | 253    | Alkaline Permanganate Method (Subbiah and Asija, 1956) |
| 5.      | Available phosphorus (kg ha⁻¹) | 30     | Olsen’s Method (Jackson, 1967)              |
| 6.      | Available potassium (kg ha⁻¹) | 320    | Flame photometer Method (Jackson, 1967)    |
Since the leaves will fall down in mustard at 75 days after sowing only hence the leaf area readings were recorded at 75 DAS only.

Note: AH-After harvest, DAS-Days after sowing.

**Number of primary and secondary branches**

With respect to number of primary branches per plant in mustard soile mustard recorded higher number of primary branches at all growth stages and there was no significant difference was noticed with number of primary branches in mustard at 30 DAS. At 60 DAS, sole mustard recorded higher number of primary branches (8.0) and was on par with 3:1 (7.3) and 5:1 (7.7). The increase in primary branches at 60 DAS and at harvest was to the tune of 3.89 and 12.04 per cent respectively. The increases in primary branches were due to increase in vegetative growth of sole mustard. Among intercropping treatments, higher number of primary were recorded in 2:1 (7.0) and 3:1(7.3). At harvest also 5:1 row ratio of chickpea + mustard recorded higher number of primary branches per plant (8.3) and on par with 3:1 (7.7). With respect to secondary branches per plant At 30 DAS, there were no secondary branches are borne. Hence observations were recorded at 60 DAS and at harvest only.At 60 DAS, among intercropping treatments, higher number of secondary branches per plant was recorded in 5:1 row ratio of chickpea + mustard (14.6) which was on par with 2:1 and 3:1 row ratio (13.6 and 14.3). Significantly lower numbers of secondary branches per plant were found with 4:4 row ratio of chickpea + mustard (10.6). At harvest also, in intercropping system, higher number of secondary branches per plant was recorded in 5:1 row ratio of chickpea + mustard (15.3) and on par with 3:1 and 2:1 (15.2 and 14.3 respectively). Significantly lower secondary branches per plant were found with 4:4 row ratio of chickpea + mustard (11.1).

**Leaf area**

The observations with respect to leaf area was recorded at 30, 60 and at 75 DAS and are presented in Table 3. Treatments differ with respect to leaf area due to different row ratio of chickpea and mustard. Sole mustard recorded leaf area of 4.44 dm² plant⁻¹. The increase with leaf area to an extent of 4.75, 8.69 and 3.80 per cent respectively, over 5:1 row ratio of chickpea + mustard at 30 DAS in sole chickpea. Among intercropping treatments, higher leaf area was recorded in 5:1 row ratio of chickpea + mustard (4.21 dm²) and found on par with 3:1 and 2:1 row ratio (4.03 and 3.86 dm² plant⁻¹, respectively). Higher leaf area was due to higher vegetative growth, less competition from intercrop which led to higher leaf area in 5:1 row ratio of chickpea + mustard. Significantly lower (3.08 dm²) leaf area was found with 4:4 row ratio of chickpea + mustard at 30 DAS. At 60 DAS also treatment with sole crop of mustard recorded higher leaf area of 11.61 dm² plant⁻¹ and on par with 2:1, 3:1 and 5:1 (10.22, 10.69 and 10.68 dm² plant⁻¹ respectively). In intercropping system, higher leaf area was recorded with 5:1 ratio of chickpea + mustard (10.68 dm²) and which was on par with 3:1, 2:1 and 8:2 row ratio (10.68, 10.22 and 8.80 dm² plant⁻¹ respectively). Sole mustard recorded higher leaf area (12.27 dm² plant⁻¹) at 75 DAS also and was found on par with 2:1, 3:1 and 5:1 (10.83, 11.61 and 11.82 dm² plant⁻¹ respectively). Among intercropping treatments, 5:1 row ratio recorded higher leaf area (11.82 dm² plant⁻¹) and on par with 3:1 and 2:1 (11.61 dm² and 10.83 dm² respectively) row ratio of chickpea + mustard at 75 DAS.

**Total dry matter production**

Data related to total dry matter production per plant at 30, 60 DAS and at harvest was recorded and presented in Table 4. Higher dry matter production was noticed with sole mustard at 30, 60 DAS and at harvest (3.50, 36.60 and 42.70 g plant⁻¹, respectively). Treatments didn’t differ with respect to total dry matter production at 30 DAS. However, numerically higher dry matter production was found with sole mustard (3.50 g plant⁻¹). At 60 DAS, higher dry matter was noticed in sole mustard treatment (36.60 g plant⁻¹) and on par with 2:1, 3:1 and 32.83, 33.46 and 34.30 g plant⁻¹, respectively) and intercropping of chickpea + mustard (5:1) recorded higher total dry matter production of 34.30 g plant⁻¹.

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**Table 3:** Growth parameters of mustard as influenced by different row ratio of chickpea and mustard intercropping system.

| Treatment                      | Plant height (cm) | No. of primary branches | No. of secondary branches | Leaf area (dm² plant⁻¹) |
|--------------------------------|-------------------|-------------------------|---------------------------|-------------------------|
|                                | 30 DAS | 60 DAS | AH | 30DAS | 60DAS | AH | 60DAS | AH | 30DAS | 60DAS | 75DAS |
| T1 Chickpea + mustard (2:1)    | 37.0   | 145.9  | 150.2 | 0.93 | 7.0  | 7.3  | 13.6 | 14.3  | 3.86 | 10.22 | 10.83 |
| T2 Chickpea + mustard (3:1)    | 37.4   | 151.3  | 154.9 | 1.00 | 7.3  | 7.7  | 14.3 | 15.2  | 4.03 | 10.69 | 11.61 |
| T3 Chickpea + mustard (3:3)    | 35.3   | 134.1  | 139.4 | 0.67 | 5.7  | 6    | 11.1 | 12.1  | 3.26 | 8.10  | 8.43  |
| T4 Chickpea + mustard (4:2)    | 35.8   | 137.2  | 141.1 | 0.73 | 6.0  | 6.3  | 12.0 | 13.6  | 3.37 | 8.23  | 8.80  |
| T5 Chickpea + mustard (4:4)    | 35.0   | 133.6  | 136.1 | 0.60 | 5.0  | 5.7  | 10.6 | 11.1  | 3.08 | 8.00  | 8.31  |
| T6 Chickpea + mustard (5:1)    | 37.6   | 154.1  | 159.0 | 1.00 | 7.7  | 8.3  | 14.6 | 15.3  | 4.21 | 10.68 | 11.82 |
| T7 Chickpea + mustard (6:2)    | 36.1   | 140.2  | 143.0 | 0.80 | 6.3  | 6.7  | 12.3 | 13.3  | 3.46 | 8.53  | 9.12  |
| T8 Chickpea + mustard (8:2)    | 36.7   | 141.1  | 145.4 | 0.87 | 6.7  | 7.0  | 13.1 | 13.6  | 3.50 | 8.80  | 9.18  |
| T9 Sole mustard                | 38.3   | 157.3  | 163.0 | 1.00 | 8.0  | 9.3  | 15.3 | 16.1  | 4.44 | 11.61 | 12.27 |
| S.Em±                          | 1.37   | 5.27   | 5.46  | 0.04 | 0.26 | 0.28 | 0.60 | 0.72  | 0.22 | 0.70  | 0.43  |
| C.D. (P<0.05)                  | NS     | 15.81  | 16.37 | 0.12 | 0.78 | 0.85 | 1.83 | 2.15  | 0.68 | 2.11  | 1.30  |

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Table 4: Total dry matter production, seed yield, stalk yield and harvest index of mustard as influenced by row ratio of chickpea and mustard.

| Treatments                        | Total dry matter production (g plant⁻¹) | Seed yield (kg ha⁻¹) | Stalk yield (kg ha⁻¹) | Harvest index (%) |
|-----------------------------------|----------------------------------------|----------------------|-----------------------|-------------------|
|                                   | 30 DAS       | 60 DAS       | At harvest           |                   |                   |
| T1 Chickpea + mustard (2:1)       | 2.60         | 32.83        | 38.65                | 866               | 2771              | 23.82 |
| T2 Chickpea + mustard (3:1)       | 2.81         | 33.46        | 39.91                | 811               | 2581              | 23.92 |
| T3 Chickpea + mustard (3:3)       | 2.40         | 22.80        | 30.00                | 1073              | 2945              | 26.93 |
| T4 Chickpea + mustard (4:2)       | 2.54         | 23.10        | 31.20                | 816               | 2638              | 26.60 |
| T5 Chickpea + mustard (4:4)       | 2.32         | 22.00        | 28.30                | 1128              | 2994              | 27.62 |
| T6 Chickpea + mustard (5:1)       | 2.82         | 34.30        | 41.01                | 658               | 2576              | 20.27 |
| T7 Chickpea + mustard (6:2)       | 2.33         | 24.01        | 32.70                | 476               | 2082              | 18.65 |
| T8 Chickpea + mustard (8:2)       | 2.48         | 25.30        | 34.80                | 405               | 1889              | 17.65 |
| T9 Sole mustard                   | 3.50         | 36.60        | 42.70                | 1723              | 4294              | 23.76 |
| S.Em±                             | 0.26         | 1.33         | 1.27                 | 50                | 112               | 1.37  |
| C.D. (P=0.05)                     | NS           | 3.99         | 3.81                 | 149.9             | 336               | 4.11  |

NS-Non significant.

and on par with intercropping treatments 2:1, 3:1 and (32.83 and 33.46 g plant⁻¹, respectively). Considerably lower dry matter production was noticed with 4:4 row ratio of chickpea + mustard (22 g plant⁻¹). At harvest also sole mustard recorded higher dry matter production (42.70 g plant⁻¹) and found on par with 3:1 and 5:1 (39.91 and 41.01 g plant⁻¹, respectively). With respect to intercropping treatments, chickpea and mustard at seeding ratio of 5:1 recorded higher dry matter production (41.01 g plant⁻¹) and found on par with 2:1, 3:1 and (38.65 and 39.91 g plant⁻¹, respectively) and lower dry matter was found with 4:4 row ratio of chickpea + mustard (28.30 g plant⁻¹). These results are similar with the findings of Vinaykant (2005) in chickpea + mustard intercropping system.

Seed yield
The variations were noticed with respect to seed yield due to different row ratio of chickpea and mustard (Table 4). Sole mustard recorded significantly higher seed yield (1723 kg ha⁻¹). The increase in seed yield in sole mustard is to the tune of 52.7 and 60.57 per cent over 4:4 and 3:3 row ratio of chickpea + mustard, respectively. This might be due to higher plant population (Table 3) under sole cropping of mustard, absence of competition from component crop and limited disturbance of habitat. These results are similar with the findings of Singh et al. (1992), Das et al. (1992) and Ahlawat et al (2005) who also stated that higher seed yield was due to higher plant population at maturity under sole cropping as compared to inter cropping combinations and also The result of this investigation also get supported from those obtained by Kumar and Nandan (2007) Kumar and Singh (2006), Kumar et al. (2006), Tripathi et al. (2005b), Ahlawat et al. (2005a) and Thakur et al. (2000). Among intercropping, 4:4 ratio recorded higher seed yield of 1128 kg ha⁻¹ and found on par with 3:3 row ratio of chickpea + mustard (1073 kg ha⁻¹). Significantly lower seed yield was noticed in 8:2 row ratio of chickpea + mustard (405 kg ha⁻¹). The higher yields in 4:4 row ratio might be due to higher population (Table 3) per unit area of mustard at maturity. These results corroborate the results of Vinaykant (2005) and Guruvindarsingh (2005) who also stated that, increase in population (Table 3) per unit area increases the vegetative growth and dry matter production which reflected in seed yield of mustard.

Stalk yield
Significant differences were noticed with respect to stalk yield of mustard due to different row ratio of chickpea and mustard (Table 4). Treatment with sole mustard recorded significantly higher stalk yield of mustard (4294). Stalk yield was increased to the extent of 43.4 and 45.8 per cent in sole mustard over 4:4 and 3:3 row ratio of chickpea + mustard. With respect to intercropping system, 4:4 row ratio of chickpea + mustard recorded higher stalk yield (2994 kg ha⁻¹) which was on par with 3:3 row ratio of chickpea + mustard (2945 kg ha⁻¹) and 2:1 row ratio of chickpea + mustard (2771 kg ha⁻¹). Significantly lower stalk yield recorded with 8:2 row ratio of chickpea + mustard (1889 kg ha⁻¹).

Harvest index
Harvest index differed due to different row ratio of chickpea and mustard and are presented in Table 4. Higher harvest index was recorded in sole mustard (28.72%) and found on par with 3:3 (26.93%) and 4:4 (27.62%). The increase in harvest index in sole mustard was to the tune of 3.98 and 6.64 per cent over 4:4 and 3:3 row ratio of chickpea + mustard, respectively. This was obviously due to more plant population of mustard (Table 3). With respect to intercropping system, 4:4 row ratio of chickpea + mustard recorded higher harvest index (27.62%) and on par with 2:1 (23.82%), 3:1(23.92%), 3:3(26.93 %) and 4:2 (26.60%). The increase in harvest index in 4:4 ratio to the tune of 2.56 per cent over 3:3 row ratio of chickpea + mustard. This might be due to more population (Table 2) of mustard per unit area which intern produced more dry matter of mustard. Significantly lower harvest index was recorded with 8:2 row ratio of chickpea + mustard (17.65%) (Table 4). Harvest index differed due to different row ratio of chickpea and mustard.
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Table 5: Oil content of mustard as influenced by different row ratio of chickpea and mustard intercropping system.

| Treatment                          | Oil content (%) | Oil yield (kg ha⁻¹) |
|-----------------------------------|-----------------|---------------------|
| T₁ Chickpea + mustard (2:1)       | 34.11           | 294.94              |
| T₂ Chickpea + mustard (3:1)       | 33.88           | 274.75              |
| T₃ Chickpea + mustard (3:3)       | 34.22           | 366.70              |
| T₄ Chickpea + mustard (4:2)       | 34.40           | 277.93              |
| T₅ Chickpea + mustard (4:4)       | 34.52           | 389.35              |
| T₆ Chickpea + mustard (5:1)       | 34.90           | 232.00              |
| T₇ Chickpea + mustard (6:2)       | 34.22           | 162.98              |
| T₈ Chickpea + mustard (8:2)       | 34.47           | 139.54              |
| T₉ Sole mustard                    | 35.16           | 606.00              |
| S.Emz                             | 1.21            | 17.65               |
| C.D. (P=0.05) NS                   |                 |                     |

NS-Non significant.

Mainly due to higher seed yield. These results are in conformity with the findings of Kumar et al. (2001) in lentil based intercropping system.

**CONCLUSION**

India’s population is expected to reach 1.51 billion by the end of 2030 which creates vegetable oil demand of 34 million tonnes for satisfying the oilseed requirements and also to supply the pulses demand for ever increasing population under decreasing land availability vertical expansion of land by means of intercropping is a viable option. So keeping in view of all these considerations it can be concluded that intercropping of chickpea + mustard in 4:4 row ratio can be recommended in Northern Transition Zone of Karnataka.

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