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# Performance of chickpea as influenced by mulching practices in maize-chickpea cropping system

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**Abstract**
The field experiment was carried out at MARS, Dharwad during *kharif* and *rabi* season of 2013-14 and 2014-15 to study the performance of chickpea as influenced by mulching practices in maize-chickpea cropping system. The experiment comprised two vertical strip treatments like, maize grown with *kharif* mulch and without mulch in *kharif* and horizontal sub plot treatments (*rabi* crops with mulch and *rabi* crops without mulch in chickpea). Results showed that yield, yield parameters, available moisture and economics varied significantly among the mulching practices. Though all the mulch treatments improved the available soil moisture status, both season mulched was found superior in maintaining optimum soil moisture condition for crop use. The residual soil moisture was also minimum, indicating effective utilization of moisture by the crop under the mulching treatment. The results were showed that maize grown with mulching practices recorded significantly higher grain yield (8.34 t/ha) of maize as compared to without mulching practice (7.20 t/ha of grain yield). Both seasoned mulching treatment was recorded significantly higher the grain yield of chicpea (1.83 t/ha) as compared to without mulching practices (1.37 t/ha). The economic analysis also revealed that the maximum benefits could be obtained from both seasoned mulch (Rs. 35631/ha) as compared to without mulch treatment (Rs. 21936/ha). Benefit-cost ratio was highest in both seasoned mulch (2.7) lowest in without mulch treatment (2.1).

**Keywords:** Maize-chickpea cropping system, Mulching, Nutrient uptake

## Introduction
The retention of crop residues on the soil surface is a key principle for reducing surface water runoff and erosion. A mulch of crop residues enhances water infiltration and protects the soil from sealing and crusting by rainfall. Under semi-arid conditions surface plant residues also play an important role in conservation of soil water through reduced soil evaporation. The profitability of higher yield of *rabi* crops is mainly depends on stored soil moisture and rainfall after sowing of *rabi* crops. Rainfall after sowing of *rabi* crops in October-November is a chance factor. Therefore, the soil moisture at sowing largely determines the productivity of winter crops with good weather conditions prevailing thereafter. Hence, moisture is the major constraint in crop production during *rabi* season. This constraint can be alleviated by effective moisture conservation practices [2]. The main objective of this study was to establish to what extent mulch effects on crop water balance may reduce production risk associated with rainfall variability. As a means of taking into account complex interactions between management practices and soil and weather conditions, application of residues as mulch and analyzed the effects of surface residue on production risk associated with rainfall variability at Zone VIII. Since, the transportation of mulch materials in the crop field may be critical problem in some areas. Therefore, in situ generation of different mulch materials is of great significance in rainfed farming. With this back ground the experiment was conducted for two years to study the effect crop residue used as mulching on chickpea grain yield, stored and available moisture and economics of maize-chickpea cropping system.

## Matrial and Methods
Field experiment was carried out during *kharif* and *rabi* season of 2013-14 and 2014-15 at Dharwad, Karnataka (15º 26′ N latitude, 75º 07′ E longitude and at an altitude of 678 m above mean sea level) under rainfed conditions to evaluate the effect of mulching practices on wheat grain yield, stored moisture, available moisture and economics of maize-chickpea cropping system. The experimental site has deep black soil with a pH (7.3), organic C (0.66%), available N (264 kg/ha), $P_2O_5$ (28.54 kg/ha) and $K_2O$ (356.8 kg/ha). The experiment laid out in randomized complete block design. In *kharif*, maize was grown with and without mulch in strips followed by chicpea was sown in each strip with and without mulch. Mulching was done at after one intercultivation. The varieties used are Maize 'Cargill M-900 super gold (sown on

24th June 2013 and 16th July 2014 respectively). Chickpea 'A 1 was sown on 06th November during 2013-14 and 09th November during 2014-15. The plot was 40.5x7.2m as strips and sub plot was 7.2x9.5m and sub sub plot was 7.2x4.5m. The recommended doses of fertilizers were applied to crops (maize (100:50:50:30). At the time of sowing 50% N along with full dose of P and K were applied. The remaining 50% N was top dressed at 30 DAS. All the cultural and plant protection measures were adopted as per the sate recommendations. The total rainfall received during 2013-14 was 707.6 mm with 63 rainy days. The rainfall received during cropping period was 456.20 mm (June to October) and 2.2 mm (November to March), respectively. The total rainfall received during 2014-15 was 1056 mm with 71 rainy days. The rainfall received during cropping period was 490.6 mm (July to November and 196.2 mm (November to March). There was no much variation in weather during the cropping period like relative humidity and maximum and minimum temperature in both the years. Five plants were selected randomly from the second row of the each plot for the measurements of plant height, leaf area and dry matter accumulation. Leaf area index was computed by dividing the leaf area to ground area. After harvesting, threshing, cleaning and drying, the grain yield was recorded. Straw yield was obtained by subtracting grain yield from the total biomass yield. The economics were calculated based on prevailing market prices of inputs and out puts. Net returns for the crops were computed on the basis of grain and straw yield, their prevailing market prices and cost of cultivation. Benefit: cost ratio was computed by dividing the net returns by total cost of cultivation. Total nitrogen, phosphorous and potassium uptake of wheat at different stages were calculated for each treatment separately using the following formula and the uptake of N, P and K were expressed in kg/ha.

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Per cent nutrient concentration}}{100} \times \text{biomass (kg ha}^{-1})$$

**Nutrient use efficiency**

Nutrient use efficiency is measured by several ways like Apparent Recovery (AR) and Agronomic Efficiency (AE). These parameters are derived using formula,

$$AR_{N/P/K}\ (\%) = \frac{\text{Total N/P/K uptake from treated plot (kg/ha)} - \text{Total N/P/K uptake from control plot (kg/ha)}}{\text{Amount of N/P/K applied (kg/ha)}} \times 100$$

$$AE_{N/P/K}\ (\text{kg ha}^{-1}) = \frac{\text{Grain yield in treated plot (kg/ha)} - \text{Grain yield in control plot (kg/ha)}}{\text{Amount of N/P/K applied (kg/ha)}}$$

**Results**

***Growth attributes of chickpea:*** Application of residue mulch in both *kharif* and *rabi* treatment recorded significantly higher plant height (38.0 cm) as compared to control (28.8 cm) (Table 1). Application of residue mulch during *kharif* and *rabi* recorded significantly higher number of primary branches (10.00) as compared to without mulch treatment (control) (6.00) at harvest stage in pooled analysis. Significantly higher number of secondary branches was recorded with the application of residue mulch in *kharif* and *rabi* (28.00) as compared to control (22.50).

***Yield and yield attributes of chickpea:*** Number of pods plant$^{-1}$ was significantly higher in treatment receiving mulch in both *kharif* and *rabi* (56, 63 and 59.5) as compared to without mulch (43, 48 and 45.50) in 2013-14, 2014-15 and in pooled analysis, respectively (Table 3). It was on par with *rabi* only mulched treatment (49, 60 and 54.50). The same trend was observed in both the years. The grain yield per plant was significantly higher with the treatment which received mulch during both *kharif* and *rabi* season (6.75, 9.83 and 8.29 g) as compared to control (5.52, 8.75 and 7.13 g) during both the years and in pooled analysis. Test weight was significantly higher in both *kharif* and *rabi* mulched treatment (15.72, 21.09 and 18.40 g) as compared to without mulched treatment (control) (10.14, 15.68 and 12.91 g) during 2013-14, 2014-15 and in pooled analysis, respectively. It was on par with only *rabi* mulched treatment (13.85, 19.82 and 16.84 g). The same trend was observed in both the years. Application of mulch during both *kharif* and *rabi* recorded significantly higher grain yield (1612, 2146 and 1879 kg ha$^{-1}$) as compared to without mulched treatment (control) (1193, 1545 and 1369 kg ha$^{-1}$) during 2013-14, 2014-15 and in pooled analysis, respectively. However it was on par with only *rabi* mulched treatment (1430, 2048 and 1739 kg ha$^{-1}$) during 2013-14, 2014-15 and in pooled analysis, respectively.

***Nitrogen, phosphorous and potassium uptake of chickpea:*** Nitrogen, phosphrous and potassium uptake was found to be significantly influenced due to mulching treatments. In chickpea, both season mulched treatment recorded significantly higher nitrogen (84.20 kg ha$^{-1}$), phosphorus (9.46 kg ha$^{-1}$) and potassium (58.56 kg ha$^{-1}$) uptake as compared to non mulched treatment (60.40, 6.05 and 40.95 kg ha$^{-1}$ N, P and K) at harvest stage in pooled analysis (Table 4).

***Apparent nitrogen and phosphorus recovery use efficiency in chickpea:*** Apparent nitrogen and phosphorus recovery efficiency was significantly influenced due to mulching treatments. Application of mulch during both *kharif* and *rabi* recorded higher nitrogen (189.93, 286.07 and 238.00%) and phosphorus use efficiency (11.27, 16.03 and 13.65%) in 2013-14, 2014-15 and pooled analysis, respectively as compared to control (Table 5 & 6).

***Economics:*** The economic analysis also revealed that the maximum benefits could be obtained from both seasoned

mulch (Rs. 35631/ha) as compared to without mulch treatment (Rs. 21936/ha) (Table 7).

## Discussion

Mulching during *kharif* to maize followed by mulches to chickpea during *rabi* treatment recorded significantly higher total number of branches (38.00 at harvest) as compared to without mulch to both the crops (control) (28.50) at harvest in pooled analysis. Similar trend was observed in both the individual years. Significantly higher leaf area was recorded with treatment which received mulch during both *kharif* and *rabi* season (2.06 $dm^2$ $plant^{-1}$) as compared to other treatments. Mulching during both the seasons recorded significantly higher LAI in pooled analysis as compared to without mulch treatment. Similar trend was noticed in both the years. Total dry mater production was significantly higher with mulch to both crops in *kharif* and *rabi* (14.93 g $plant^{-1}$) as compared to control (10.07 g $plant^{-1}$) at harvest in pooled analysis. The differences in yield components of chickpea could be traced back to the differences in growth parameters at all the stages of crop growth (Sharanakumar, 2008). The higher total dry matter production of chickpea at all the stages of crop growth (Table 1) in mulched plots may be due to differential residual effect and addition of mulching material which generated favourable environment for crop growth and development [7]. Higher translocation of photosynthates to pods at harvest in mulched plot was due to higher sink capacity as indicated by more number of leaves and higher uptake of nutrients [6]. Further, it was reflected by higher LA (Table 2) and LAI (Table 2). LA and LAI increased upto 60 DAS and decreased there after drastically. Similarly, both plant height and number of branches were higher with mulching as compared to without mulching practice. This was due to enhanced uptake of nutrients and moisture and ultimately increased in grain yield. Similar results were reported by [11] and [1] in mungbean.

The higher yield and higher soil nutrient status as a result of higher biomass. Further, decomposition of residue resulted in higher availability of N, P and K which helped in increased uptake of nutrients. Similar results were also reported by several workers [5, 9, 3, 4, 7]. The enhanced moisture and nutrient contribution due to added mulch material led to increased biomass production and hence higher N uptake. Similar results were observed [7]. Significantly higher agronomic nitrogen efficiency (41.90, 60.10 and 51.00 kg/ha) and phosphrous efficiency (16.76, 24.04 and 20.40 kg/ha) was recorded in both seasoned mulched as compared to without mulched treatments. Benefit-cost ratio was highest in both seasoned mulch (2.7) lowest in without mulch treatment (2.1). Similar results were found by Sharma *et al.* (2011a, 2011b) and Ramesh (2013).

Application of mulch during both *kharif* and *rabi* recorded significantly higher haulm yield (1828, 2443 and 2136 kg $ha^{-1}$) as compared to without mulched treatment (control) (1352, 1784 and 1568 kg $ha^{-1}$) during 2013-14, 2014-15 and in pooled analysis, respectively. [7, 6] also reported that, incorporation of crop residue increased the yield of chickpea. The higher grain yield in chickpea could be attributed to higher nutrient and moisture availability in soil and further decomposition of added crop residue material as mulch, which resulted in buildup of organic matter content of the soil and uptake of applied nutrients by the succeeding crop. Higher yield could be attributed to better expression of yield components such as grain weight $plant^{-1}$ which in turn depends on 100 grain weight and number of pods $plant^{-1}$ [10]. Mulching by virtue of its capacity to maintain soil temperature and soil moisture influenced greater accumulation of photosynthates. The improved performance of yield attributes may be related to increased availability of nitrogen in soil as a consequent of addition of higher biomass as reflected in the available nitrogen status after harvest of chickpea [10]. The increased yield of mulched plots is due to increase in yield per unit area which in turn depends on yield parameters *viz.*, no. of pods per plant, grain yield per plant, and test weight. The grain yield per plant was significantly higher with both season much plot (6.75, 9.83 and 8.29 g) as compared to non-mulched plot (5.52, 8.75 and 7.13 g) and the test weight was also higher in same above said treatments during 2013-14, 2014-15 and in pooled data.

**Table 1:** Growth attributes of chickpea at harvest as influenced by mulching practices

| Treatments | Plant height (cm) | | | Number of primary branches | | | Secondary branches | | | Total number of branches | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled |
| *Kharif* maize fb chickpea without mulch (control) | 27.5 | 30.1 | 28.8 | 5.00 | 7.00 | 6.00 | 20.00 | 25.00 | 22.50 | 25.00 | 32.00 | 28.50 |
| *Kharif* maize grown with mulch fb chickpea without *kharif* mulch | 33.8 | 35.4 | 34.6 | 6.00 | 8.00 | 7.00 | 23.00 | 27.00 | 25.00 | 29.00 | 35.00 | 32.00 |
| *Kharif* maize without mulch fb chickpea with *kharif* mulch | 30.8 | 37.6 | 34.2 | 8.00 | 10.00 | 9.00 | 25.00 | 29.00 | 27.00 | 33.00 | 39.00 | 36.00 |
| *Kharif* maize grown with mulch fb chickpea with *kharif* mulch | 36.6 | 39.4 | 38.0 | 9.00 | 11.00 | 10.00 | 26.00 | 30.00 | 28.00 | 35.00 | 41.00 | 38.00 |
| S.Em± | 1.65 | 1.75 | 1.63 | 0.58 | 0.58 | 0.58 | 0.93 | 0.87 | 0.89 | 1.52 | 0.96 | 1.22 |
| CD at 5% | 5.72 | 6.07 | 5.66 | 2.00 | 2.00 | 2.00 | 3.21 | 3.00 | 3.07 | 5.25 | 3.31 | 4.21 |

**Table 2:** Growth attributes chickpea harvest as influenced by mulching

| Treatments | Leaf area ($dm^2$ $plant^{-1}$) | | | Leaf area index | | | Total dry matter production (g $plant^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled |
| *Kharif* maize fb chickpea without mulch (control) | 1.32 | 1.58 | 1.45 | 0.44 | 0.53 | 0.48 | 9.04 | 11.09 | 10.07 |
| *Kharif* maize grown with mulch fb chickpea without *kharif* mulch | 1.53 | 1.68 | 1.60 | 0.51 | 0.56 | 0.54 | 10.00 | 13.85 | 11.93 |
| *Kharif* maize without mulch fb chickpea with *kharif* mulch | 1.67 | 1.98 | 1.83 | 0.56 | 0.66 | 0.61 | 11.75 | 13.72 | 12.74 |
| *Kharif* maize grown with mulch fb chickpea with *kharif* mulch | 1.77 | 2.35 | 2.06 | 0.59 | 0.78 | 0.69 | 13.05 | 16.82 | 14.93 |
| S.Em± | 0.06 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.62 | 0.63 | 0.41 |
| CD at 5% | 0.20 | 0.10 | 0.11 | 0.07 | 0.07 | 0.06 | 2.15 | 2.19 | 1.41 |

**Table 3:** Yield attributes of chickpea as influenced by mulching practices

| Treatments | Number of pods per plant | | | Grain yield per plant (g) | | | Test weight (100 seed in g) | | | Grain yield (t ha$^{-1}$) | | | Haulm yield (t ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled |
| *Kharif* maize fb chickpea without mulch (control) | 43.00 | 48.00 | 45.50 | 5.52 | 8.75 | 7.13 | 10.14 | 15.68 | 12.91 | 1.19 | 1.54 | 1.37 | 1.35 | 1.78 | 1.57 |
| *Kharif* maize grown with mulch fb chickpea without *kharif* mulch | 46.00 | 56.00 | 51.00 | 6.34 | 9.55 | 7.95 | 11.79 | 17.72 | 14.75 | 1.32 | 1.92 | 1.62 | 1.42 | 2.15 | 1.78 |
| *Kharif* maize without mulch fb chickpea with *kharif* mulch | 49.00 | 60.00 | 54.50 | 6.56 | 9.67 | 8.11 | 13.85 | 19.82 | 16.84 | 1.43 | 2.05 | 1.74 | 1.65 | 2.33 | 1.99 |
| *Kharif* maize grown with mulch fb chickpea with *kharif* mulch | 56.00 | 63.00 | 59.50 | 6.75 | 9.83 | 8.29 | 15.72 | 21.09 | 18.40 | 1.61 | 2.15 | 1.88 | 1.83 | 2.44 | 2.14 |
| S.Em± | 2.30 | 2.50 | 2.38 | 0.06 | 0.06 | 0.03 | 0.52 | 0.51 | 0.48 | 55 | 053 | 49 | 31 | 49 | 29 |
| CD at 5% | 7.97 | 8.65 | 8.24 | 0.22 | 0.20 | 0.10 | 2.05 | 1.76 | 1.66 | 193 | 187 | 172 | 106 | 169 | 100 |

NS – Non-significant fb – followed by

**Table 4:** Nitrogen, phosphorus and potassium uptake (kg ha$^{-1}$) in chickpea at harvest as influenced by mulching

| Treatments | Nitrogen uptake (kg ha$^{-1}$) | | | Phosphorous uptake (kg ha$^{-1}$) | | | Potassium uptake (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled |
| *Kharif* maize fb chickpea without mulch (control) | 52.57 | 68.23 | 60.40 | 5.09 | 7.00 | 6.05 | 35.64 | 46.26 | 40.95 |
| *Kharif* maize grown with mulch fb chickpea without *kharif* mulch | 55.85 | 84.60 | 70.23 | 5.77 | 8.94 | 7.36 | 38.67 | 58.16 | 48.41 |
| *Kharif* maize without mulch fb chickpea with *kharif* mulch | 63.17 | 91.87 | 77.52 | 6.77 | 10.51 | 8.64 | 43.73 | 64.31 | 54.02 |
| *Kharif* maize grown with mulch fb chickpea with *kharif* mulch | 71.56 | 96.84 | 84.20 | 7.91 | 11.00 | 9.46 | 49.20 | 67.93 | 58.56 |
| S.Em± | 1.86 | 1.84 | 1.52 | 0.24 | 0.34 | 0.16 | 0.96 | 1.24 | 0.87 |
| CD at 5% | 6.43 | 6.37 | 5.26 | 0.83 | 1.18 | 0.54 | 3.33 | 4.28 | 3.02 |

NS – Non-significant fb – followed by

**Table 5:** Effect of mulching practices on nitrogen use efficiency in chickpea as influenced by mulching practices

| Treatments | Apparent nitrogen recovery efficiency (%) | | | Agronomic efficiency (kg/ha) | | |
|---|---|---|---|---|---|---|
| | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled |
| *Kharif* maize fb chickpea without mulch (control) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *Kharif* maize grown with mulch fb chickpea without *kharif* mulch | 32.83 | 163.67 | 98.25 | 12.87 | 37.27 | 25.07 |
| *Kharif* maize without mulch fb chickpea with *kharif* mulch | 106.03 | 236.40 | 171.22 | 23.63 | 50.30 | 36.97 |
| *Kharif* maize grown with mulch fb chickpea with *kharif* mulch | 189.93 | 286.07 | 238.00 | 41.90 | 60.10 | 51.00 |
| S.Em± | 18.59 | 18.41 | 15.20 | 5.48 | 5.31 | 4.86 |
| CD at 5% | 64.33 | 63.70 | 52.59 | 18.97 | 18.38 | 16.82 |

**Table 6:** Effect of mulching practices on phosphorous use efficiency of chickpea as influenced by mulching practices

| Treatments | Apparent phosphorous recovery efficiency (%) | | | Agronomic efficiency (kg/ha) | | |
|---|---|---|---|---|---|---|
| | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled |
| *Kharif* maize fb chickpea without mulch (control) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *Kharif* maize grown with mulch fb chickpea without *kharif* mulch | 2.69 | 7.79 | 5.24 | 5.15 | 14.91 | 10.03 |
| *Kharif* maize without mulch fb chickpea with *kharif* mulch | 6.69 | 14.07 | 10.38 | 9.45 | 20.12 | 14.79 |
| *Kharif* maize grown with mulch fb chickpea with *kharif* mulch | 11.27 | 16.03 | 13.65 | 16.76 | 24.04 | 20.40 |
| S.Em± | 0.96 | 1.37 | 0.63 | 2.19 | 2.12 | 1.94 |
| CD at 5% | 3.32 | 4.73 | 2.17 | 7.59 | 7.35 | 6.73 |

fb – followed by

**Table 7:** Economics of chickpea as influenced by mulching practices

| Treatments | Gross Returns (Rs./ha) | | | Net Returns (Rs./ha) | | | B:C Ratio | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled |
| *Kharif* maize fb chickpea without mulch (control) | 35800 | 47112 | 41456 | 18225 | 25646 | 21936 | 2.04 | 2.19 | 2.12 |
| *Kharif* maize grown with mulch fb chickpea without *kharif* mulch | 39660 | 58479 | 49069 | 22085 | 37013 | 29549 | 2.26 | 2.73 | 2.49 |
| *Kharif* maize without mulch fb chickpea with *kharif* mulch | 42890 | 62454 | 52672 | 24074 | 38720 | 31397 | 2.28 | 2.63 | 2.46 |
| *Kharif* maize grown with mulch fb chickpea with *kharif* mulch | 48370 | 65443 | 56906 | 29554 | 41709 | 35631 | 2.57 | 2.76 | 2.67 |
| S.Em± | 1645 | 1620 | 1470 | 1645 | 1620 | 1470 | 0.09 | 0.07 | 0.07 |
| CD at 5% | 5691 | 5605 | 5087 | 5691 | 5605 | 5087 | 0.31 | 0.25 | 0.25 |

*- CoC- Rs.15790/ha (2013-14) *- CoC- Rs.18286/ha (2013-14)
-CoC-Rs.17031/ha

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