**International Journal of Agriculture Sciences**
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 7, Issue 3, 2015, pp.-454-459.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

# MOISTURE CONSERVATION PRACTICES IN BLACKGRAM (*Vigna mungo*) BASED INTERCROPPING SYSTEM UNDER RAINFED CONDITION

**CHHETRI B.*, DAHAL D., MAHATO S.K. AND KHAWAS T.**

Regional Research Station, Hill Zone, Uttar Banga Krishi Viswavidyalaya, Kalimpong - 734 301, WB, India.
*Corresponding Author: Email- yonib2050@gmail.com

Received: April 27, 2015; Revised: May 25, 2015; Accepted: May 27, 2015

**Abstract-** A study was carried out to investigate the growth attributes and economics of blackgram (*Vigna mungo*)-based intercropping systems as influenced by moisture conservation practices. The experiment was laid out in a split –plot design with three replications with four cropping systems of C1-sole blackgram, C2-sole sesame, C3-blackgram + sesame (2:2) and C4-sesame + blackgram (2:4) were assigned to main plots and four moisture conservation practices viz. M0= without mulch and irrigation, M1=Dry weed biomass mulch @ 5.0 t ha$^{-1}$, M2=FYM mulch @ 5.0 t ha$^{-1}$ and M3=Irrigation as and when require were assigned to sub plots. Among the moisture conservation practices, irrigation (twice) recorded the highest growth attributing characters followed by FYM mulch and dry weed bio mass mulch. Among the cropping systems, highest plant height, number of branches plant$^{-1}$, leaf area index and dry matter accumulation was recorded in blackgram grown as sole crop but when blackgram grown as intercrop, highest growth attributing characters was recorded under 2:4 row ratio combination followed by 2:2 row ratio combination. Among the methods of moisture conservation practices, the highest economics return was recorded under irrigation (twice) followed by FYM mulch and dry weed bio mass mulch. Among the cropping systems, the highest yield attributes and economics returns was recorded under when blackgram grown as sole crop but when blackgram grown as intercrop yield attributes and economics return was recorded highest under 2:4 row ratio combination followed by 2:2 row ratio combination. These results indicated that intercropping along with mulching helps to increase the absorption of soil moisture and reducing the loss of moisture form surface soil which help to enhances the growth and yield of blackgram.

**Keywords-** Blackgram, sesame, intercropping, moisture conservation practices, economics

**Citation:** Chhetri B., et al. (2015) Moisture Conservation Practices in Blackgram (*Vigna mungo*) based Intercropping System under Rainfed Condition. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 7, Issue 3, pp.-454-459.



## Introduction

Blackgram (*Vigna mungo*) belongs to the family *Fabaceae,* is commonly known as uradbean and considered as important source of protein in the diets of a large section of vegetarian population in the developing countries like India. It assumes considerable importance from the food and nutritional security point of view. The average productivity is low and the production is not sufficient to meet the per capita requirement. Therefore, it is very important to raise crop productivity in order to meet the food requirements of an increasing population through appropriate technology like intercropping. Intercropping, is more effective use of soil moisture, nutrients, light, suppresses weed growth and other resources and thereby significantly enhances crop productivity compared to the sole crops [1,2]. However, intercropping is the growing of two or more crops on the same piece of land within the same year to promote their interaction and it also maximizes chances of productivity by avoiding dependence on only one crop [3].

Blackgram is a short duration crop suitable for multiple cropping and intercropping systems and this provides opportunity for including blackgram as an ideal legume crop in intercropping system because diversification of rice-rice and rice-wheat cropping system by introduction of suitable pulse crops is also in the national interest which must be popularized. Legume intercropping systems play a significant role in the efficient utilization of resources and cereal-legume intercropping is a more productive and profitable cropping system in comparison with solitary cropping [4] by increasing production per unit area [5]. Moreover, various intercropping patterns of legumes and non-legumes (legumes with cereals and oilseeds) have been a central feature of many agricultural systems in tropics and subtropics [6,7].

Moisture conservation practices are the key to successful crop production in dry and rainfed areas [8]. Since major source of soil moisture loss from field is evapo-transpiration, a favorable regulation like intercropping is needed to go a long way in overcoming the problem of soil moisture loss. The intercropping system, besides increasing productivity and profitability also conserves the soil moisture [9,10]. Besides intercropping system, application of organic manure also served as a mulch material and played a significant role in soil moisture conservation [11].

Therefore, intercropping systems and mulching in these regions assumes considerable importance from the point of conservation and utilization of soil moisture in the most judious way. Considering the above mentioned reason, a study on growth and yield responses to various moisture conservation practices on blackgram based intercropping system was carried out under Terai region of West Bengal.

## Materials and Methods

In order to study the effect of growth and yield of blackgram (*Vigna mungo*) based intercropping system as influenced by moisture conservation practices. The field experiment was carried out at Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Coochbehar, West Bengal, India during 2014. The farm is situated at 26$^{o}$1986' N latitude and 89$^{o}$2353' E longitude and at an elevation of 43 meters above mean sea level. The soil of the experimental field was sandy loam in texture with pH 5.7. The treatments consisted of four cropping systems C1-sole blackgram, C2- sole sesame, C3- blackgram + sesame (2:2) and C4- sesame + blackgram (2:4) were assigned to main plots and four levels of moisture conservation practices M0 = without mulch and irrigation, M1= dry weed biomass mulch @ 5.0 t ha$^{-1}$, M2 = FYM mulch @ 5.0 t ha$^{-1}$ and M3 = Irrigation as and when require were assigned to sub plots. The experiment was laid out in a split – plot design with three replications. The results were analyzed taking consideration of pre-harvest parameters like plant height (cm), number of branches plant$^{-1}$, leaf area index (LAI), dry matter accumulation (DMA) at 20, 40, 60 (DAS) and at harvest where as post - harvest parameters viz. number of pods and capsule plant$^{-1}$, test weight (g), seed yield (kg ha$^{-1}$) and stem yield (kg ha$^{-1}$). Economics were worked out for gross return, net returns and benefit cost ratio were calculated based on the prevailing input prices and the output based on the MSP or prevailing market prices for crops. The data collected from the field was analyzed statistically and the treatment variation was listed for significance by F test [12]. For determination of critical differences at 5% level of significance, Fisher & Yates [13] table were consulted.

## Result and Discussion

### Effect of Treatments on Growth

Irrespective of cropping systems and methods of moisture conservation practices, plant height kept on increasing till the last observation recorded at harvest. The plant height and number of primary branches (except 20 DAS) increased with the advancement of the crop age due to its growth and reached its maximum at harvest irrespective of the treatments tried [Table-1].

**Table 1-** Plant height and number of primary branches plant$^{-1}$ of blackgram as influenced by cropping systems and soil moisture conservation practices

| Cropping systems (C) | | Plant height (cm.) Days after sowing | | | | Number of primary branches plant$^{-1}$ Days after sowing | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 20 | 40 | 60 | At harvest | 20 | 40 | 60 | At harvest |
| C1 | | 12.39 | 17.43 | 28.17 | 29.2 | 4.04 | 6.47 | 7.11 | 7.94 |
| C3 | | 11.13 | 16.45 | 26.89 | 27.92 | 3.58 | 5.99 | 6.36 | 7.46 |
| C4 | | 12.21 | 17.22 | 27.97 | 29 | 3.64 | 6.05 | 6.69 | 7.52 |
| S. Em(±) | | 0.423 | 0.567 | 0.056 | 0.056 | 0.227 | 0.03 | 0.031 | 0.033 |
| C.D. (0.05) | | NS | 0.157 | 0.157 | 0.157 | NS | 0.083 | 0.086 | 0.091 |
| Moisture Conservation practices (M) | | | | | | | | | |
| M0 | | 11.66 | 16.62 | 26.86 | 27.73 | 3.46 | 5.56 | 6.01 | 6.66 |
| M1 | | 11.8 | 16.81 | 27.34 | 28.32 | 3.63 | 5.91 | 6.09 | 6.96 |
| M2 | | 11.9 | 22.2 | 27.76 | 28.84 | 3.88 | 6.39 | 7.28 | 8.22 |
| M3 | | 12.28 | 17.36 | 28.74 | 29.92 | 4.04 | 6.82 | 7.76 | 8.74 |
| S.Em(±) | | 0.531 | 0.05 | 0.05 | 0.056 | 0.398 | 0.022 | 0.024 | 0.026 |
| C.D. (0.05) | | NS | 0.106 | 0.106 | 0.015 | NS | 0.046 | 0.05 | 0.054 |
| Interaction | | | | | | | | | |
| C1M0 | | 11.99 | 16.96 | 27.2 | 28.07 | 3.96 | 6.15 | 6.68 | 7.25 |
| C1M1 | | 12.21 | 17.23 | 27.76 | 28.74 | 4.01 | 6.29 | 6.47 | 7.34 |
| C1M2 | | 12.34 | 17.4 | 28.24 | 29.32 | 4.06 | 6.57 | 7.46 | 8.38 |
| C1M3 | | 13.03 | 18.13 | 29.51 | 30.69 | 4.12 | 6.9 | 7.84 | 8.82 |
| C3M0 | | 11.02 | 15.97 | 26.21 | 27.08 | 3.18 | 5.25 | 5.78 | 6.34 |
| C3M1 | | 11.11 | 16.12 | 26.65 | 27.63 | 3.43 | 5.71 | 5.89 | 6.76 |
| C3M2 | | 11.15 | 16.17 | 27.01 | 28.09 | 3.76 | 6.27 | 7.16 | 8.11 |
| C3M3 | | 11.27 | 16.32 | 27.7 | 28.88 | 3.96 | 6.74 | 7.68 | 8.66 |
| C4M0 | | 11.99 | 16.96 | 27.2 | 28.07 | 3.24 | 5.31 | 5.84 | 6.4 |
| C4M1 | | 12.09 | 17.11 | 27.64 | 28.62 | 3.46 | 5.74 | 5.92 | 6.79 |
| C4M2 | | 12.22 | 17.22 | 28.06 | 29.14 | 3.84 | 6.35 | 7.24 | 8.16 |
| C4M3 | | 12.56 | 17.63 | 29.01 | 30.19 | 4.04 | 6.82 | 7.76 | 8.75 |
| S. Em (±) | (CiMi-CiMj) | 0.92 | 0.088 | 0.089 | 0.091 | 0.689 | 0.038 | 0.041 | 0.042 |
| | (CiMi-CjMj) | 0.902 | 0.095 | 0.096 | 0.097 | 0.638 | 0.044 | 0.051 | 0.053 |
| C.D (0.05) | (LSD 0.05) | NS | 0.262 | 0.263 | 0.26 | NS | 0.114 | 0.116 | 0.12 |
| | (LSD 0.05) | NS | 0.314 | 0.315 | 0.31 | NS | 0.152 | 0.154 | 0.161 |

C1= Sole blackgram; C3= Blackgram + sesame (2:2); C4= Sesame + blackgram (2:4); M0=Without mulch and irrigation; M1=Dry weed bio-mass mulch @ 5.0 t ha$^{-1}$; M2= FYM mulch @ 5.0 t ha$^{-1}$; M3= Irrigation [2 No's- i) at vegetative stage (25-30 DAS) and ii) at flowering stage (45-50 DAS)]

The different stages of crop growth revealed that cropping systems significantly influenced the plant height at 40, 60 DAS and at harvest. In different cropping systems and moisture conservation practices, leaf area index was low at the early stages of crop growth and kept on increasing with advancement of crop age up to 60 DAS. Thereafter it declined till maturity of the crop. Irrespective of cropping systems and moisture conservation practices, the rate of dry matter accumulation increased at an increasing rate up to 60 DAS and thereafter it increased with decreasing rate. The initial growth rate as measured by the dry matter accumulation was slow at vegetative stages of crop growth which packed up as the crop passes through the seed filling and maturity stage. Dry matter accumulation was lowest at 20 DAS thereafter rapid accumulation of dry matter was noticed till at harvest.

### Growth Attributes

Among the cropping systems, sole crop of blackgram recorded higher plant height but when blackgram grown as intercrop highest plant height was recorded under 2:4 row ratio combination [Table-1]. Among the moisture conservation practices, irrigation (twice) recorded significantly higher plant height followed by FYM mulch and dry weed biomass mulch at all stages of crop growth. The control plot produced the shortest plants height might be due to severe crop competition between component crop for nutrients, moisture, light and space. Intercropping between maize - legume systems increases in plant height under sole crop was due to the wider space, available soil moisture and reduced the competition of light and nutrients, which probably provided favorable physical environment and helped the plant to grow taller [14]. Among the cropping systems, sole crop of blackgram significantly produced highest number of primary branches plant$^{-1}$ at all the stage of crop growth except 20 DAS and lowest number of primary branches plant$^{-1}$ were recorded when blackgram was intercropped with sesame (2:2 row ratio combination) [Table-1]. Among the moisture conservation practices, significantly higher number of primary branches plant$^{-1}$ was recorded with irrigation (twice) followed by FYM mulch and dry weed bio-mass mulch at all stages of crop growth except 20 DAS. This might be due to moisture conservation practices enhanced the growth and development of blackgram [15].

**Table 2-** Leaf area index and dry matter accumulation of black gram as influenced by cropping systems and soil moisture conservation practices

| Cropping systems (C) | | Leaf area index | | | | Dry matter accumulation (g m$^{-2}$) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Days after sowing | | | | Days after sowing | | | |
| | | 20 | 40 | 60 | At harvest | 20 | 40 | 60 | At harvest |
| C1 | | 1.3 | 2.34 | 3.36 | 2.83 | 172.84 | 381.97 | 572.96 | 635.98 |
| C3 | | 1.13 | 2.2 | 3.22 | 2.7 | 159.84 | 353.25 | 529.88 | 588.17 |
| C4 | | 1.26 | 2.31 | 3.33 | 2.81 | 165.35 | 365.42 | 548.14 | 608.43 |
| S. Em(±) | | 0.052 | 0.004 | 0.004 | 0.137 | 1.009 | 2.231 | 3.346 | 3.714 |
| C.D. (0.05) | | 0.143 | 0.012 | 0.019 | NS | 2.803 | 6.194 | 9.289 | 10.31 |
| Moisture Conservation practices (M) | | | | | | | | | |
| M0 | | 1.18 | 2.23 | 3.25 | 2.72 | 158.47 | 350.24 | 525.36 | 583.14 |
| M1 | | 1.28 | 2.26 | 3.28 | 2.75 | 162.87 | 359.95 | 539.92 | 599.31 |
| M2 | | 1.25 | 2.31 | 3.33 | 2.81 | 168.86 | 373.2 | 559.8 | 621.37 |
| M3 | | 1.38 | 2.34 | 3.36 | 2.83 | 173.82 | 384.15 | 576.23 | 639.61 |
| S. Em(±) | | 0.146 | 0.007 | 0.007 | 0.481 | 0.834 | 1.845 | 2.768 | 3.073 |
| C.D. (0.05) | | NS | 0.029 | 0.03 | NS | 1.754 | 3.876 | 5.816 | 6.456 |
| Interaction | | | | | | | | | |
| C1M0 | | 1.27 | 2.31 | 3.33 | 2.8 | 167.66 | 370.54 | 555.81 | 616.94 |
| C1M1 | | 1.29 | 2.33 | 3.35 | 2.82 | 169.11 | 373.74 | 560.61 | 622.27 |
| C1M2 | | 1.31 | 2.35 | 3.37 | 2.84 | 176.05 | 389.08 | 583.62 | 647.82 |
| C1M3 | | 1.34 | 2.38 | 3.4 | 2.88 | 178.53 | 394.55 | 591.82 | 656.92 |
| C3M0 | | 1.09 | 2.13 | 3.15 | 2.63 | 145.79 | 322.2 | 483.3 | 536.46 |
| C3M1 | | 1.1 | 2.18 | 3.2 | 2.67 | 155.72 | 344.13 | 516.2 | 572.98 |
| C3M2 | | 1.16 | 2.25 | 3.27 | 2.75 | 163.8 | 362 | 542.99 | 602.72 |
| C3M3 | | 1.19 | 2.27 | 3.29 | 2.77 | 174.07 | 384.7 | 577.06 | 640.53 |
| C4M0 | | 1.21 | 2.25 | 3.27 | 2.75 | 161.98 | 357.98 | 536.98 | 596.04 |
| C4M1 | | 1.24 | 2.28 | 3.3 | 2.78 | 163.79 | 361.99 | 542.98 | 602.71 |
| C4M2 | | 1.28 | 2.35 | 3.37 | 2.85 | 166.75 | 368.52 | 552.79 | 613.59 |
| C4M3 | | 1.31 | 2.38 | 3.4 | 2.87 | 168.88 | 373.21 | 559.82 | 621.4 |
| S.Em (±) | (CiMi-CiMj) | 0.253 | 0.121 | 0.013 | 0.831 | 1.446 | 3.196 | 4.794 | 5.322 |
| | (CiMi-CjMj) | 0.225 | 0.011 | 0.012 | 0.732 | 1.608 | 3.555 | 5.333 | 5.919 |
| C.D (0.05) | (LSD 0.05) | NS | 0.036 | 0.038 | NS | 4.296 | 9.495 | 14.24 | 15.814 |
| | (LSD 0.05) | NS | 0.035 | 0.037 | NS | 5.384 | 11.901 | 17.85 | 15.815 |

C1= Sole blackgram; C3= Blackgram + sesame (2:2); C4= Sesame + blackgram (2:4); M0=Without mulch and irrigation; M1=Dry weed bio-mass mulch @ 5.0 t ha$^{-1}$; M2= FYM mulch @ 5.0 t ha$^{-1}$; M3= Irrigation [2 No's- i) at vegetative stage (25-30 DAS) and ii) at flowering stage (45-50 DAS)]

Moreover, moisture conservation was greatly increased by imposition of mulches on soil surface. Mulch application particularly increased the availability of soil moisture [16] and reduced [17] the moisture loss from surface soil and improved the micro environment to the crops. Control plot produced the lowest number of primary branches. This was due to severe crop competition for nutrients, moisture, light and space. Irrespective of cropping systems and moisture conservation practices, sole crop of blackgram recorded significantly the higher leaf area index than blackgram + sesame intercropping situation at all the stages of crop growth [Table-2]. The moisture conservation practices significantly influenced the leaf area index. The highest leaf area index was recorded with irrigation (twice) followed by FYM mulch and dry weed bio-mass mulch and lowest leaf area index was recorded under control plot due to severe crop competition at all the stages of crop growth except 20 DAS [Table-2]. Leaf area index was significantly higher in sole crop compared to the intercropped systems in different ratio [18]. The dry matter accumulation was significantly higher from the sole crop of blackgram than the blackgram intercropped with sesame due to increased number of primary branches, plant height and leaf area index.

Among the methods of moisture conservation practices, significantly higher dry matter accumulation was recorded at irrigation (twice) followed by FYM mulch and dry weed biomass mulch at all the stages of crop growth [Table-2]. Adequate supply of moisture positively influenced on the growth and dry matter production of crop directly as well as indirectly by increasing the availability and utilization of moisture by crop [19]. This might have also reduced the competition between main crop and intercrop for growth sources because of shorter duration and non-spreading nature [8].

### Yield Attributes of Blackgram

Among the cropping systems, sole crop of blackgram produced significantly higher yield attributing characters like number of pods plant$^{-1}$ and test weight as compared to blackgram intercropped with sesame and produced significantly the higher seed yield and stem yield. Intercropping of blackgram with sesame produced the highest number of pods plant$^{-1}$ under 2:4 row ratio combination (intercropping system). Similar results were also reported by Chhetri et al [20]. Blackgram intercropped with maize significantly influenced the growth in terms of number of branches and lateral spread along with yield advantage [21]. Moisture conservation practices, irrigation (twice) significantly influenced the number of pods plant$^{-1}$, test weight followed by FYM mulch and dry weed biomass mulch. The lowest yield attributes was recorded under the control plot and interaction effects between treatments was found to be significant [Table-3].

**Table 3-** Yield attributes and yield of blackgram and sesame as influenced by cropping systems and soil moisture conservation practices

| Cropping systems (C) | | No. of pods plant$^{-1}$ | Test weight (g) | Stem yield (kg. ha$^{-1}$) | Seed yield (kg. ha$^{-1}$) | No. of capsule plant$^{-1}$ | Test weight (g) | Stem yield (kg. ha$^{-1}$) | Seed yield (kg. ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| C1 | | 48.39 | 6.83 | 1,359 | 953 | - | - | - | - |
| C2 | | - | - | - | - | 73.87 | 2.85 | 1541 | 785 |
| C3 | | 42.6 | 6.77 | 1,256 | 882 | 67.11 | 2.63 | 945 | 588 |
| C4 | | 44.4 | 6.66 | 1,300 | 912 | 71.18 | 2.71 | 1356 | 671 |
| S.Em(±) | | 0.264 | 0.006 | 8.01 | 5.57 | 1.059 | 0.03 | 59.61 | 19.1 |
| C.D. (0.05) | | 0.733 | 0.017 | 22.24 | 15.47 | 2.939 | 0.085 | 165.47 | 53.03 |
| Moisture Conservation practices (M) | | | | | | | | | |
| M0 | | 45.66 | 6.74 | 1,312 | 874 | 67.06 | 2.66 | 981 | 565 |
| M1 | | 45.04 | 6.76 | 1,258 | 899 | 69.51 | 2.71 | 1,238 | 632 |
| M2 | | 44.97 | 6.76 | 1,211 | 932 | 72.04 | 2.74 | 1,351 | 724 |
| M3 | | 45.03 | 6.75 | 1,439 | 959 | 74.27 | 2.82 | 1,155 | 804 |
| S. Em (±) | | 0.271 | 0.01 | 9.33 | 4.61 | 0.6 | 0.025 | 37.01 | 32.08 |
| C.D. (0.05) | | NS | 0.03 | 19.61 | 9.68 | NS | 0.535 | 77.75 | 67.4 |
| Interaction | | | | | | | | | |
| C1M0 | | 48.92 | 6.85 | 1,390 | 925 | - | - | - | - |
| C1M1 | | 47.94 | 6.84 | 1,292 | 933 | - | - | - | - |
| C1M2 | | 48.24 | 6.82 | 1,242 | 971 | - | - | - | - |
| C1M3 | | 48.47 | 6.81 | 1,471 | 985 | - | - | - | - |
| C2M0 | | - | - | - | - | 69.21 | 2.87 | 1,225 | 666 |
| C2M1 | | - | - | - | - | 72.57 | 2.81 | 1,489 | 740 |
| C2M2 | | - | - | - | - | 76.36 | 2.82 | 1,614 | 815 |
| C2M3 | | - | - | - | - | 77.36 | 2.94 | 1,836 | 920 |
| C3M0 | | 43.14 | 6.75 | 1,179 | 804 | 64.51 | 2.57 | 665 | 487 |
| C3M1 | | 42.94 | 6.77 | 1,215 | 859 | 65.43 | 2.61 | 912 | 503 |
| C3M2 | | 42.47 | 6.79 | 1,141 | 904 | 67.39 | 2.66 | 1,011 | 666 |
| C3M3 | | 42.14 | 6.78 | 1,389 | 960 | 71.11 | 2.72 | 1,193 | 698 |
| C4M0 | | 44.93 | 6.61 | 1,321 | 894 | 67.46 | 2.57 | 1,052 | 543 |
| C4M1 | | 44.26 | 6.68 | 1,267 | 904 | 70.53 | 2.73 | 1,313 | 653 |
| C4M2 | | 44.21 | 6.67 | 1,184 | 920 | 72.4 | 2.75 | 1,428 | 692 |
| C4M3 | | 44.49 | 6.69 | 1,383 | 932 | 74.37 | 2.81 | 1,631 | 794 |
| S. Em (±) | (CiMi-CiMj) | 0.01 | 11.43 | 7.98 | 7.98 | 1.04 | 0.01 | 71.84 | 0.47 |
| | (CiMi-CjMj) | 0.011 | 12.73 | 8.88 | 8.88 | 1.39 | 0.05 | 83.26 | 0.48 |
| C.D (0.05) | (LSD 0.05) | 0.01 | 33.97 | 23.72 | 23.72 | 3.09 | NS | 215.51 | NS |
| | (LSD 0.05) | 0.04 | 42.66 | 29.72 | 29.72 | 4.9 | NS | 249.77 | NS |

C1= Sole blackgram; C2= Sole sesame; C3= Blackgram + sesame (2:2); C4= Sesame + blackgram (2:4); M0=Without mulch and irrigation; M1=Dry weed biomass mulch @ 5.0 t ha$^{-1}$; M2= FYM mulch @ 5.0 t ha$^{-1}$; M3= Irrigation [2 No's- i) at vegetative stage (25-30 DAS) and ii) at flowering stage (45-50 DAS)]

Among the cropping systems, sole crop of blackgram produced significantly higher seed yield and stem yield as compared to sesame + blackgram (2:4 and 2:2) intercropping systems. The method of moisture conservation practices, irrigation (twice) significantly produced higher seed yield and stem yield followed by FYM mulch and Dry weed bio-mass mulch [Table-3]. The higher yield and yield components in moisture conservation practices could be attributed to vigorous crop growth resulting from increased availability of soil moisture in sorghum Mudalagiriyappa et al [19] and Das & Goutham [21] in pearl millet. Control plot recorded the lowest seed yield and stem yield [Table-3].

### Yield Attributes and Yields of Sesame

The number of capsules plant$^{-1}$ and test weight was significantly influenced when sesame was intercropped with blackgram and there was an increasing trend with respect to sole sesame due to the development of both temporal and spatial complimentarily as a result of which there was no competition for nitrogen and there was a possibility of current transfer of fixed nitrogen to the crop. Among the cropping systems, sole crop of sesame significantly produced highest seed yield and stem yield might be due to increased growth and yield attributing characters like number of branches plant$^{-1}$, number of capsule plant$^{-1}$ and test weight. Among the cropping systems, sesame + blackgram (2:4) intercropping systems significantly recorded higher seed yield and stem yield [Table-3] followed by sesame + blackgram (2:2). Higher yield of intercrops in paired row planting (2:2 and 2:4 row ratio combination) might be due to less competition for space and light which might have supported higher translocation of photosynthetic from source to sink resulting higher yield [20,23]. When sesame was intercropped with blackgram significantly recorded higher number of capsules plant$^{-1}$ and test weight. Seed yields of sesame can also increase on intercropping with soybean and black gram [9,27]. Among the methods of moisture conservation practices, significantly highest number of capsule plant$^{-1}$ and test weight (1000 seed weight) was recorded under irrigation (twice) followed by FYM mulch and dry weed biomass mulch and resulted highest seed yield and stem yield. The lowest seed yield and stem yield was recorded under control treatment. This might be due to severe crop competition for nutrients, moisture, light and space. Similar results also made by Chhetri et al [20].

### Economics

The maximum net returns and benefit cost ratio (0.98) was observed in the treatment C1M3 followed by the treatment C1M1 giving net return and return cost ratio (1.09), So, we can say that at C2M3 the maximum return could be found and at C1M1 and C1M0. The highest (Rs. 47,699 ha$^{-1}$) gross return was recorded under when blackgram grown as sole (C1). Sesame + blackgram intercropping situation (2:4) recorded higher gross return (Rs. 45,632 ha$^{-1}$) (C4) followed by blackgram + sesame (2:2) intercropping situation (Rs. 44,112 ha$^{-1}$) (C3). Among the methods of moisture conservation practices, gross income was recorded to be maximum (Rs. 49,269 ha$^{-1}$) when blackgram was grown alone combined with irrigation (twice) (C1M3) followed by black gram + sesame intercropping situation (2:2) combined with irrigation (twice) (C3M3) (Rs. 48,039 ha$^{-1}$) [Table-4].

Net income (Rs. 22,793 ha$^{-1}$) was recorded to be maximum for blackgram when grown alone (C1). Sesame + blackgram intercropping situation (2:4) recorded higher net income (Rs. 21,252 ha$^{-1}$) (C4) followed by sesame + blackgram (2:2) intercropping situation (Rs. 19,827 ha$^{-1}$) (C3). The net return and B: C ratio recorded higher under 2: 4 row ratio combination might be due to less reduction in blackgram yield and increased yield of intercrops as compared to other row arrangements. The similar findings of economics benefits from intercropping systems Ahlawat & Gangaiah [24] in chickpea and linseed intercropping systems and Hargilas & Ameta [25] in maize and onion. Among the methods of moisture conservation practices, maximum net return (Rs. 24,333 ha$^{-1}$) was recorded when blackgram grown as sole combined with irrigation (twice) (C1M3) followed by blackgram when grown alone combined with dry weed bio mass mulch (C1M1) (Rs. 24,292 ha$^{-1}$) [Table-4]. Moisture conservation by straw mulching significantly influenced the net return and B: C ratio over spreading of FYM mulch and no mulch in Linseed [26].

B: C ratio was recorded to be maximum (0.94) for blackgram when grown alone (C1). Sesame + Blackgram intercropping situation (2:4) recorded higher B: C ratio (0.90) (C4). Among the methods of moisture conservation practices, B: C ratio was recorded to be maximum (1.09) when blackgram was grown alone combined with dry weed bio mass mulch (C1M1) [Table-4]. Similar results were also obtained [27,28] in which under mulching treatment, moisture conservation was better resulting in higher availability of moisture to the crop under rainfed condition.

**Table 4-** Effect of treatments on economics of blackgram

| Treatment | Gross return (Rs.) | Net return (Rs.) | B:C ratio |
|---|---|---|---|
| C1 | 47699 | 22793 | 0.94 |
| C3 | 44112 | 19827 | 0.84 |
| C4 | 45632 | 21252 | 0.9 |
| C1M0 | 46270 | 23892 | 1.07 |
| C1M1 | 46670 | 24292 | 1.09 |
| C1M2 | 48586 | 18655 | 0.62 |
| C1M3 | 49269 | 24333 | 0.98 |
| C3M0 | 40234 | 18475 | 0.85 |
| C3M1 | 42973 | 21214 | 0.98 |
| C3M2 | 45204 | 15893 | 0.54 |
| C3M3 | 48039 | 23724 | 0.98 |
| C4M0 | 44703 | 22849 | 1.05 |
| C4M1 | 45203 | 23349 | 1.07 |
| C4M2 | 46019 | 16614 | 0.56 |
| C4M3 | 46605 | 22194 | 0.91 |

C1= Sole black gram C3= Black gram + Sesame (2:2), C4= Sesame + Black gram (2:4) M0=Without Mulch and Irrigation, M1=Dry weed bio-mass mulch @5.0 t ha$^{-1}$.M2= FYM Mulch @5.0 t/ha.M3= Irrigation [2 No's- i) at vegetative stage (25-30 DAS) and ii) at flowering stage (45-50 DAS)]

### Conclusion

These results indicated that intercropping along with mulching helps to increase the absorption of moisture and reducing the loss of moisture by evaporation. Legume and non- legume intercropping systems has been found to be relatively more productive and profitable as compared to sole cropping of individual component crops.

**Conflicts of Interest:** None declared.

### References

[1] John S.A. & Mini C. (2005) *Journal of Tropical Agriculture,* 43(1-2), 33-36.

[2] Eskandari H. & Ghanbari A. (2009) *Notulae Botanicae Horti*

*Agrobotanici Cluj-Napoca,* 37(2), 152-155.

[3] Sullivan P. (2003) *Intercrop Principles and practices (Agronomy Systems Guide)*, ATTRA- National Sustainable Agriculture Information Service, 1-12.

[4] Evans J., Mcneill A.M., Unkovich M.J., Fettell N.A. & Heenan D.P. (2001) *Australian Journal of Experimental Agriculture*, 41, 347-359.

[5] Zhang L., Werf W., Zhang S., Li B. & Spiertz J.H.J. (2007) *Field Crops Research,* 103, 178-188.

[6] Willey R.W. (1979) *Field Crop Abstract*, 32, 1-10.

[7] Davis J. & Smithson J.B. (1986) *Principles of intercropping with beans*, Centro International De Agricultura Tropical, Cali, Colombia.

[8] Kumar A. & Rana K.S. (2007) *Indian Journal of Agronomy*, 52 (1), 31-35.

[9] Padhi A.K. & Panigrahi R.K. (2006) *Indian Journal of Agronomy*, 51(3), 174-177.

[10] Singh U., Saad A.A. & Singh S.R. (2008) *Indian Journal Agriculture Science,* 78(12), 1023-1027.

[11] Rana K.S., Shivran R.K. & Kumar A. (2006) *Indian Journal of Agronomy*, 51(1), 24-26.

[12] Gomez A.K. & Gomez A.A. (1983) *Statistical Procedures of Agricultural Research*, An IRRI Book, John Wiley and Sons, New York.

[13] Fisher R.A. & Yates F. (1949) *Statistical tables for biological, agricultural and medical research*, ed. 3.

[14] Hugar H.Y. & Palled Y.B. (2008) *Karnataka Journal of Agriculture Science*, 21(2), 159-161.

[15] Reddy P.R.R. & Mohammad S. (2008) *Journal of Agro meteorology*, 10(2), 158-164.

[16] Fuchs M. & Hadas A. (2011) *Agricutural Water Management,* 98, 990-998.

[17] Yuan C., Lei T., Mao L., Liu H. & Wu Y. (2009) *Catena*, 78, 117-121.

[18] Choudhary V.K., Suresh K.P. & Bhagawati R. (2012) *International Journal of Science and Nature*, 3(1), 41-46.

[19] Ramachandrappa B.K. & Nanjappa H.V. (2012) *Agricultural Sciences*, 3(4), 588-593

[20] Chhetri B., Mahata D., Mahato S.K. & Sinha A.C. (2014) *Green Farming*, 5(5), 782-785.

[21] Pathak K. & Singh N.P. (2008) *Journal of Farming Systems Research and Development*, 14(1), 29-34

[22] Das G. & Goutham R.C. (2003) *Annals of Agricultural Research*, 24, 78-81.

[23] Latha P.M., Prasad P.V.N. & Subramanyam K. (2008) *Agricultural Science Digest*, 28(1), 48-50.

[24] Ahlawat I.P.S., Gangaiah B. (2010) *Indian Journal of Agriculture Sciences*, 80(3), 248-249.

[25] Hargilas & Ameta G.S. (2015) *Green Farming*, 6(2), 323-326.

[26] Singh R.K., Singh A. & Singh K. (2014) *Environment and Ecology*, 32(2), 425-427.

[27] Pandey D.K. & Nath V. (2008) *Indian Journal of Soil Conservation*, 36, 188-191.

[28] Sharma A.R, Singh R., Dhyani S.K. & Dube R.K. (2011) *Journal of crop Improvement*, 25, 392-408.