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Evaluation of maize based intercropping system under dryland situation at Bastar plateau zone of Chhattisgarh

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Abstract
The present research entitled “Evaluation of Maize based Intercropping System under Dryland Situation at Bastar Plateau Zone of Chhattisgarh” was conducted at Research Cum Instructional Farm, S.G. College of Agriculture and Research Station, Jagdalpur, IGKV, Chhattisgarh during *Kharif* 2023. The experiment was laid out in RBD with three replications. The treatments comprised of T1: Maize Sole, T2: Cowpea Sole, T3: Pigeon pea Sole, T4: *Jhudga* Sole, T5: Maize + Cowpea (4:2), T6: Maize + Pigeon pea (4:2), T7: Maize + *Jhudga* (4:2). With respect to biological efficiency, the intercropping system of Maize + Cowpea (T5) exhibited the highest values for ATER and LER, followed by Maize + Jhudga (T7) and Maize + Pigeon pea (T6). It also recorded the highest system productivity and MGEY among all treatments. The highest level of aggressivity was observed in the Maize + Pigeon pea (T6) intercropping system, followed by Maize + Jhudga (T7) and Maize + Cowpea (T5). Among the various intercropping systems, the intercropping treatment Maize + Cowpea (T5) had a significantly higher gross return and net return in terms of economics. This was followed by Maize + *Jhudga* (T7) and Maize + Pigeonpea (T6). Cowpea-sole (T2) had the best benefit cost ratio of any sole crop, while maize-sole (T1) had the highest net returns and gross returns.

Keywords: Maize based intercropping system

1. Introduction
One of the most adaptable developing crops, maize (*Zea mays* L.) has a larger range of adaptability to different agroclimatic conditions. Because it has the largest genetic production potential of all the cereals, maize is referred to as the "queen of cereals" throughout the world (Anonymous, 2022) [2].

Using compatible crops in the right row proportions is crucial for intercropping success. There are two methods for growing intercrops with primary crops: replacement and additive series. Whereas in replacement series, intercrops replace main crop rows or populations, additive series adjusts additional intercrop populations with total main crop populations per unit area. Intercropping with replacement series is a common and practical strategy in densely seeded crops, especially in rain-fed environments (Kaushik *et al*., 2016) [4].

Singh and Singh, (2001) [13] when compared the yield of sole crops to maize-equivalent crops, all intercropping schemes performed better. Among different intercropping patterns of maize and soybean, paired maize rows + 2 rows of soybean gave the highest total yield and maize equivalent yield.

Sharma *et al*. (2008) [11] result revealed that the association of maize and cowpea in row ratio 2:2 exhibited the highest land-equivalent ratio, followed by maize + rice bean in 2:2 ratio. Among the component crops, maize was more competitive and aggressive than legume intercrops. However, maize intercropped with cowpea and rice bean both in row proportion 2: l was found to be a compatible intercropping system with lower values of aggressivity (0.01) and competition ratio (1.03).

Kheroar and Patra, (2013) [5] observed that intercropped legumes enhanced maize's yield components and provided some additional yield. The combination of maize + green gram (1:1) and maize + peanut (1:1) produced the maximum yields of maize grains and maize equivalent, respectively. Maize + Black Gram (1:2) recorded the higher values of land equivalent ratio, area

time equivalent ratio and land equivalent coefficient. The values of all the competition functions were consistently larger than unity.

Peiwang and Dawson, (2021) [10] findings revealed that highest land equivalent ratio and maize equivalent yield for the treatment Maize + Green gram in 2:2 row ratio. Also, highest gross returns, net returns and B:C ratio was recorded for the same treatment.

Sharma *et al*. (2008) [11] a field experiment was conducted during the summer season of 2006 and 2007 at Sabour, Bihar to assess the economic viability of intercropping system. Intercropping of maize and cowpea in the row proportion 2:2 recorded significantly higher dry matter as well as net returns and benefit: cost ratio compared with the other treatments except maize + rice bean planted in the ratio 2:2.

Kheroar and Patra, (2013) [5] evaluated the productivity and economic viability of maize + legume intercropping systems. Maize + peanut combination recorded the highest net return followed by maize + green gram in 1:1 and 1:2 row ratio. Similarly, among the intercropping systems, maize + peanut (1:2) obtained the highest B:C ratio of 2.76 and highest per day return in 1:1 and 1:2 row ratios.

Nandan *et al*. (2013) [8] two years experimental findings revealed that the system productivity, production efficiency and net returns with benefit -cost ratio of 2.54 and 2.32 during the year 2008-09 and 2009-10, respectively were higher in the sequence where mustard was intercropped with field pea when succeeded by maize grown in association with cowpea followed by the sequence mustard + field pea succeeded by maize in association with moong bean intercropping sequences.

Parimaladevi *et al*. (2019) [9] revealed that the combination of maize + vegetable cowpea (2:2) produced higher net returns and gross returns followed by maize + black gram (2:2). Intercropping had always been advantageous and had a higher B:C than maize monoculture. The intercropping system with the highest B:C ratio of 3.34 was with maize + vegetable cowpea (2:2) and it was followed by maize + black gram (2:2).

Shivakumar *et al*. (2020) [12] revealed that significantly higher maize equivalent yield with maize + pigeonpea (4:2) with 60 cm×20 cm spacing. Gross returns, net returns and B:C ratio was also higher with maize + pigeonpea (2:1) with 60 x 20 cm as compared to sole crop of maize or pigeonpea and other intercropping systems.

2. Materials and Methods

Experiment was conducted at the Research cum Instructional Farm, S.G. College of Agriculture and Research Station, Kumhrawand, Jagdalpur, Chhattisgarh, during the *Kharif* season of 2023. The experiment consists of seven treatments with three replications that was laid out in Randomized Block Design. Bastar Plateau comes under the three Agro-climatic zones of Chhattisgarh have sub humid climatic condition. It is located in the southernmost region. The Bastar region's topology shows diverse farming situations, including as uplands, midlands, and lowlands, with a variety of crops and cultivation techniques. During the crop growth season, 1486.70 mm of rainfall was recorded and in the cropping season, the average maximum temperature was 30.2 °C, while the average lowest temperature was 20.2 °C. The average weekly evaporation during the growing season of the crops ranged from 1.8 to 3.4 mm.

Main crop used in an experiment was maize. The Hybrid was used Hishell which is also referred as MCH-42. It is a normal *Kharif* crop. It has a yield potential of 60 q ha^{-1}. Intercrop used in an experiment are pigeonpea and cowpea. The pigeonpea variety was Yashoda-45. It is a well-known for its qualities like higher yield and healthy growth of plants. It matures within 160 - 175 days. Cowpea variety was Lalitha. The plants produce a bounty of long, light reddish brown pods, measuring 25-30 cm each. These pods are nutritious, perfect for eating fresh, shelling for dried peas, or using in a variety of culinary creations. It gets ready for harvest in just 45-50 days after planting. Another cowpea was used in intercrop was local cowpea (*Jhudga*), it is used for seed only

2.1 Maize grain equivalent yield (MGEY)

Maize equivalent yield was worked out for all the experimental units by following formula Meyyappan and Kathiresan (2012) [7].

Where, MEY= Maize equivalent yield

$$\text{MEY} = \frac{\text{Yield of maize} \times \text{Existing market price of maize}}{\text{Existing market price of maize}} + \frac{\text{Yield of intercrop} \times \text{Existing market price of intercrop}}{\text{Existing market price of maize}}$$

2.2 Land equivalent ratio (LER)

Land equivalent ratio is defined as the relative land area under sole crop that is required to produce yields achieved in intercropping. The LER was worked out by using the following formula given by Willey *et al.* (1981) [14].

$$LER = La + Lb = \left(\frac{Ya}{Sa} + \frac{Yb}{Sb}\right)$$

$$\text{LER} = \frac{\text{Yield of intercrop A}}{\text{Yield of sole crop A}} + \frac{\text{Yield of intercrop B}}{\text{Yield of sole crop B}}$$

Where, La and Lb = LER's for the crops a and b
Ya and Yb = Individual crop yield under intercropping
Sa and Sb = Individual crop yield under sole cropping

2.3 Area time equivalent ratio (ATER)

The ATER provides more realistic comparison of the yield advantage of intercropping over sole cropping than LER as it considers variation in time taken by the component crops of different intercropping systems. ATER is be defined as area needed by sole cropping to produce same yield as produce by intercropping system along with consideration of duration of crops. ATER is defined as fallows

$$ATER = \frac{(LER\ of\ maize\ x\ duration\ of\ maize) + (LER\ of\ intercrop\ x\ duration\ of\ intercrop)}{Total\ duration\ of\ intercropping\ system}$$

2.4 Aggressivity

It gives a simple measure of how much relative yield increase in species 'a' is greater than that for species 'b' in an intercropping system (McGilchrist 1965) [6]. It measures the intercrop competition by relating the yield changes of both component crops.

$$Aab = \frac{Yab}{Yaa} - \frac{Yba}{Ybb}$$

Where,
Aab = Aggressivity value for the component crop "a"
Yaa = Pure stand yield of crop "a"
Yab = Intercrop yield of crop "a"
Ybb = Pure stand yield of crop "b"
Yba = Intercrop yield of crop "b"

2.5 Cost of cultivation (Rs. ha^{-1})
Each treatment's cultivation expense (Rs. ha^{-1}) was computed taking into account current agricultural practises and input prices on the market.

2.6 Gross return (Rs. ha^{-1})
The gross return was calculated by multiplying the total grain and straw yield with prevalent market prices of the items and then was presented on ha^{-1} basis as per treatments.

$$Gross\ return\ (Rs.ha-1) = Grain\ yield\ (kg\ ha-1) \times market\ price\ of\ grain\ (Rs.kg-1)$$

2.7 Net return (Rs. ha^{-1})

$$Net\ return\ (Rs.ha-1) = Gross\ return\ (Rs.ha-1) - Cost\ of\ cultivation\ (Rs.ha-1)$$

2.8 Benefit cost ratio

$$\text{B: C ratio} = \frac{\text{Gross return (Rs.ha} - 1)}{\text{Cost of cultivation (Rs.ha} - 1)}$$

3. Result and Discussion

3.1 Biological efficiencies

3.1.1 Land Equivalent Ratio (LER)

The table represents the data of the Land equivalent ratio, which was influenced by different Maize based intercropping systems. Higher land equivalent ratio was recorded with the intercropping system of (T_5) Maize + Cowpea (4:2) followed by (T_7) Maize + *Jhudga* (4:2), (T_6) Maize + Pigeonpea (4:2). Higher land equivalent ratio with (T_7) Maize + *Jhudga* (4:2) might be due to better performance of cowpea in terms of yield as an intercrop than the sole crop conditions.

3.1.2 Area Time Equivalent Ratio (ATER)

The table represents the data of the Area Time Equivalent Ratio, which was influenced by different Maize based intercropping systems. Higher Area Time Equivalent Ratio was recorded with the intercropping system of (T_5) Maize + Cowpea (4:2) followed by (T_7) Maize + *Jhudga* (4:2) and (T_6) Maize + Pigeonpea (4:2). Higher Area Time Equivalent Ratio with (T_7) Maize + Cowpea (4:2) might be due to its lesser duration and better performance as component crop in intercropping system than the other intercrops Niger and Horse gram.

3.1.3 Aggressivity

The table represents the data of Aggressivity, which was influenced by different Maize based intercropping systems. Aggressivity was found non-significant among the treatments of different intercropping systems. Higher Aggressivity was recorded with the intercropping system of (T_6) Maize + Pigeonpea (4:2) followed by (T_7) Maize + *Jhudga* (4:2) and (T_5) Maize + Cowpea (4:2). In Maize based intercropping system, aggressivity was in favor of component crop thus it indicates that maize sole suppressed the intercrops.

3.1.4 Maize Grain Equivalent Yield (MGEY) (kg ha^{-1})

The data on MGEY of different Maize based intercropping systems was presented in table showed that it was significantly influenced by the different intercrops. Higher MGEY was recorded with the intercropping system of (T_5) Maize + Cowpea (4:2) followed by (T_7) Maize + *Jhudga* (4:2) and (T_6) Maize + Pigeonpea (4:2) and significantly superior to the treatment (T_1) Maize-sole. It was concluded that the highest Maize grain equivalent yield in the intercropped treatment (T_5) Maize + Cowpea (4:2) might be due to better utilization of the resources by the component crops in the intercropped system than the sole cropping system, which led to higher yields of both Maize as well as Cowpea.

3.1.5 System Productivity (kg ha^{-1})

The data on system productivity of different Maize based intercropping systems was presented in table shows that it was significantly influenced by the different intercrops. The highest system productivity was recorded with the intercropping system of (T_5) Maize + Cowpea (4:2) significantly superior to all the other treatment. The sole crop treatment (T_3) Pigeonpea-sole was recorded with the lowest system productivity among the different sole and intercropping systems. Highest system productivity in the intercropped treatment (T_5) Maize + Cowpea (4:2) might be due to higher total grain yield of both Maize and cowpea in the intercropped system than the other crops in intercropping system.

The above results revealed that the different intercropping system affected the biological efficiencies of maize *viz* LER, MGEY, ATER and Aggressivity. The findings with the above biological efficiencies are in accordance with findings of Parimaladevi *et al* (2019) [9], Alemayehu *et al* (2017) [1] and Iqbal *et al* (2019) [3] and Yadav *et al* (2015) [15] also made the similar observations on different intercropping system.

3.2 Economics

3.2.1 Gross returns (₹ ha^{-1})

The data regarding the gross returns of the different treatments reveals that it was significantly influenced by different Maize based intercropping systems (Table 4.9). The highest gross returns were obtained with (T_5) Maize + Cowpea (4:2) followed by (T_7) Maize + *Jhudga* (4:2) and (T_6) Maize + Pigeonpea (4:2). Among the sole crops, (T_1) Maize-sole has the highest gross returns while the lowest was obtained from the treatment (T_3) Pigeonpea-sole. Higher gross returns in (T_5) Maize + Cowpea (4:2) might be due to the better performance of both the component crops in the intercropping system.

3.2.2 Net returns (₹ ha^{-1})

The data regarding the net returns was presented in the table showed that it was significantly influenced by the different intercropping system. Highest net returns were recorded with intercropping system of treatment (T_5) Maize + Cowpea (4:2) followed by (T_7) Maize + *Jhudga* (4:2) and (T_6) Maize + Pigeonpea (4:2). Among the sole crops, (T_2) Cowpea-sole had the highest net returns. Lowest net returns obtained from the treatment (T_3) Pigeonpea-sole.

3.2.3 B:C ratio

Benefit Cost ratio for the different sole and intercropping systems was shown in the table 3. From the given data, it was evident that the Benefit Cost ratio was significantly influenced by the different cropping systems. The highest Benefit Cost ratio was obtained in the treatment (T_2) Cowpea-sole. The lowest Benefit Cost ratio was recorded with the treatment (T_3) Pigeonpea-sole.

The above results revealed that the economics of different intercropping system are in close conformity with research of Parimaladevi *et al* (2019) [9], Alemayehu *et al* (2017) [1] and Iqbal *et al* (2019) [3].

Table 1: Effects of different intercropping systems on biological efficiencies

Treatments	Aggressivity	LER	ATER
T_1: Maize sole	-	1.00	1.0
T_2: Cowpea sole	-	1.00	1.0
T_3: Pigeonpea sole	-	1.00	1.0
T_4: *Jhudga* sole	-	1.00	1.0
T_5: Maize + Cowpea (4:2)	0.01	1.36	1.5
T_6: Maize + Pigeonpea (4:2)	0.11	1.30	1.2
T_7: Maize + *Jhudga* (4:2)	0.04	1.35	1.3
S.Em±	0.02	0.02	0.01
CD (p=0.05)	0.06	0.06	0.04

Table 2: Effects of different intercropping systems on biological efficiencies

Treatments	MGEY (kg ha^{-1})	System productivity (kg ha^{-1})
T_1: Maize sole	4634.00	4634.00
T_2: Cowpea sole	3263.77	1705.32
T_3: Pigeonpea sole	2600.99	776.58
T_4: *Jhudga* sole	2664.66	928.19
T_5: Maize + Cowpea (4:2)	5712.32	5047.33
T_6: Maize + Pigeonpea (4:2)	5198.82	4455.67
T_7: Maize + *Jhudga* (4:2)	5371.36	4608.89
S.Em±	140.23	75.30
CD (p=0.05)	432.10	232.02
CV %	5.09%	6.25%

Table 3: Effects of different intercropping systems on Economics

Treatments	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	BCR
T_1: Maize sole	96855	57948	2.4
T_2: Cowpea sole	68213	46203	3.1
T_3: Pigeonpea sole	54360	27622	2.0
T_4: *Jhudga* sole	55691	31748	2.3
T_5: Maize + Cowpea (4:2)	119387	77004	2.8
T_6: Maize + Pigeonpea (4:2)	108655	64158	2.4
T_7: Maize + *Jhudga* (4:2)	112261	69189	2.6
S.Em±	1230	1152.63	0.05
CD (p=0.05)			0.16
CV %			6.60%

4. Conclusion

The experimental findings and their interpretation, as presented in the former chapters, have been summarized in this chapter. The present experiment entitled "Evaluation of Maize based Intercropping System under Dryland Situation at Bastar Plateau Zone of Chhattisgarh" 'was carried out during *Kharif* 2023 at the Research Cum Instructional Farm, SG College of Agriculture and Research Station, (IGKV) Jagdalpur, The data presented support the conclusion that in case of biological efficiencies, the highest system productivity and MGEY was found significantly superior with the intercropping system Maize + Cowpea (T_5) than other treatments. Higher ATER and LER was recorded with the intercropping system of Maize + Cowpea (T_5) while intercrop Maize + Pigeonpea (T_6) showed higher values of Aggressivity. In terms of economics, gross return and net return of intercropping treatment Maize + Cowpea (T_5) was significantly superior among the different intercropping systems while BCR was highest in Cowpea-sole (T_2).

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