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# Competitive Indices and Production of Maize (*Zea mays* L.) and Cowpea (*Vigna unguiculata*) Intercropping System as Influence by Nutrient Management Practices

Binoy Chhetri[1*] and A. C. Sinha[2]

[1]Regional Research Station (HZ), Uttar Banga Krishi Viswavidyalaya, Dungra, Kalimpong (734 301), India

[2]Dept. of Agronomy, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar (736 165), India

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**Corresponding Author**

Binoy Chhetri

*e-mail*: yonib2050@gmail.com

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## Abstract

A field experiment was conducted at Instructional Farm of UBKV, Pundibari, Cooch Behar, West Bengal during 2013 and 2014. To evaluate the yield attributes, yield and competition function of maize (*Zea mays* L.) and cowpea (*Vigna unguiculata*) intercropping system. The grain yield, stover yield and harvest index of maize were significantly higher in case of pure stand of maize than intercropping systems. Among the integrated nutrient management practices, treatment supplied 75% RDF+PSB+*Azotobacter*+vermicompost @ 5.0 t ha$^{-1}$ produced highest seed yield, stover yield, harvest index and yield attributes. The values of seed yield (938 and 943 kg ha$^{-1}$), stem yield (1421 and 1435 kg ha$^{-1}$), harvest index of cowpea (40.09 and 39.97%) and yield attributes was significantly higher in sole crop. Among the integrated nutrient management practices, treatment supplied with 75% RDF+ PSB+*Azotobacter*+vermicompost @ 5.0 t ha$^{-1}$ produced highest seed yield (833 and 837 kg ha$^{-1}$), stem yield (1349 and 1358 kg ha$^{-1}$), harvest index (38.50 and 38.54%) and yield attributes. Maize equivalent yield, competition ratio, LER, RCC, competition index, aggressivity, ATER, LEC and monetary advantage was found to be higher with 2:2 row ratio combinations. Integrated nutrient management practices, maize equivalent yield, competition ratio, LER, RCC, competition index, aggressivity, ATER, LEC and monetary advantage found to be higher under 75% RD F+PSB+Azotobacter+vermicompost @ 5.0 t ha$^{-1}$. It may be concluded that maize grown as intercrop with cowpea in 2:2 row ratio combinations and supplied with 75% RDF+PSB+*Azotobacter*+vermicompost @ 5.0 t ha$^{-1}$ ($N_3$) is best for obtaining overall gain.

***Keywords:*** Maize, cowpea, yield attributes, yield, competition indices

## 1. Introduction

Maize (*Zea mays* L.) is an annual $C_4$ plant belonging to the grassy family Poaceae, with its origin in Central America. It is the world's widely grown highland cereal and primary staple food crop in many developing countries (Ram et al., 2017). It is considered as the third most important food crop among the cereals in India and contributes to the nearly 9% of the national food basket (Jeet et al., 2017). In India, it occupies 8.69 m ha of the area with a production of 21.81 mt and 2509 kg ha$^{-1}$ productivity (Anon, 2016a). It occupies 0.16 m ha of the area with a production of 0.72 m t and 4615 kg ha$^{-1}$ productivity in West Bengal (Anon, 2016b).

In North Bengal *pre-kharif* season maize is gaining popularity among the farmers primarily because of the optimum yield potential owing

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to residual supply of nutrients from previous crops. The declining of soil fertility due to inadequate supply of nutrients and continuous growing of cereals-based cropping system at this region is the major constraint for low grain yield of cereals crop (Dadarwal et al., 2009). However, the adoption of nutrient management practices will reduce the production cost, thereby increasing the economic returns to the farmers and also increases the supply and availability of soil nutrients to the crop as well as increasing the activity of beneficial soil micro organism due to availability of more organic matter content (Mahapatra et al., 2018).

There is some evidence of decline in the productivity of *pre- kharif* maize even with the application of recommended dose of fertilizer as well as organic manure. To overcome of this problem, introduction of grain legume in cereal-based cropping system aims at increased productivity and profitability to achieve food and nutritional security and sustainability (Swaminathan, 1998). Consequently continuously growing of a same crop over years in the same cultivated area leads to ill health of the soil increases various pest and diseases (Vandermeer, 1989) and decline in productivity that can overcome by following alternate methods such as intercropping or sequential cropping (Lithourgidis et al., 2011).

Intercropping is the growing of two or more crops species on the same piece of land could mitigate the risk of crop failure (Willy, 1990).Various intercropping patterns of legumes and non-legumes have been a central feature of many agricultural systems in tropics and subtropics (CIAT, 1986). Sometimes, due to uneven distribution of rainfall decline the production of main crop and added grain legume as an intercropping system provides food for the farm household (Rusinamhodzi et al., 2012). Intercropping cropping plays an important role in agriculture because of the effective utilization of resource, significantly enhancing crop productivity compare with that monoculture (Li et al., 1999) and intercropping is widely accepted as a sustainable practice due to its yield advantage, high utilization efficiency of light, water and pest and diseases suppression (Zhu et al., 2000). Thus, better management of nutrients is especially important for increasing crop production of maize-cowpea intercropping system in terai region of West Bengal. Considering the above mentioned reason, this study was carried to find out the effects of maize-cowpea intercropping system as influenced by nutrient management practices on yield attributes, yield and competitive function.

## 2. Materials and Methods

A field experiment was conducted during *pre-kharif* seasons (February to May) of 2013 and 2014 at the Instructional Farm, UBKV, Pundibari, Coochbehar, (26°19'86" N and 89°23'53" E, 43 m above mean sea-level), West Bengal, India. The climatic condition of *tarai* zone is sub-tropical, with eminent characteristics of rainfall, high humidity and prolonged winter. Physico-chemical properties of soil were as follows–sand (64.19%), silt (20.47%), clay (15.34%) measured by International Pipette method (Piper, 1950), bulk density (1.42 g $cc^1$) measured by core sample method (Piper, 1950), field capacity (36.59%) field sample method (Piper, 1950), soil pH (5.11) measured by Potentiometric method (Jackson, 1967), Organic carbon (0.85%) measured by Tritrimetric determination (Walkley and Black, 1934), total nitrogen (211.5 kg $ha^{-1}$) measured by Modified Kjeldahl method (Jackson, 1967), available phosphorous (18.24 kg $ha^{-1}$) measured by Bray's method (Jackson, 1967) and available potassium (112.93 kg $ha^{-1}$) measured by Flame Photometer method (Jackson, 1967). The experiment was laid out in a split–plot design with three replications. Four levels of cropping system $C_1$-Sole maize, $C_2$-Sole cowpea, $C_3$-Maize+cowpea (2:2) and $C_4$-Maize+cowpea (2:4) were assigned to main plots and four levels of integrated nutrient management $N_1$: 100% RDF 80:40:40 kg $ha^{-1}$ of $N:P_2O_5:K_2O$ $N_2$: 100% RDF+Phosphate solubilising bacteria (PSB)+*Azotobacter* $N_3$:75% RDF+PSB+ *Azotobacter*+vermicompost (VC) @ 5.0 t $ha^{-1}$ and $N_4$: 50% RDF+PSB+*Azotobecter*+50% vermicompost @ 2.5 t $ha^{-1}$ for sub plot. The results were analyzed taking consideration of post harvest parameters such as number of cobs $plant^{-1}$, number of grain $cob^{-1}$, hundred seed weight (g) (100 seed weight), cob length (cm), cob girth (cm), seed yield (kg $ha^{-1}$), stover yield (kg $ha^{-1}$), harvest index (%) and number of pods $plant^{-1}$, number of seeds $pod^{-1}$, 1000 seed weight, seed yield (kg $ha^{-1}$), stem yield (kg $ha^{-1}$) and harvest index (%) for cowpea. Competition function such asaggressivity (Mc gilchrist, 1965), competition index (Donald, 1963), relative crowding co-efficient (RCC) (De Wit, 1960 and examined in details by Hall, 1974), LER (Willy and Osiru, 1972), competitive ratio (Willey and Rao, 1980), ATER (Heibsch, 1980), Land equivalent co-efficient (Adetiloye and Ezedinma, 1983) and monetary advantage (Willy, 1979), maize equivalent yield and combined yield. The data obtained from two years (2013 and 2014) studies were analyzed statistically following split- plot design as per the procedure given by Gomez and Gomez (1984).

## 3. Results and Discussion

### *3.1. Effect of cropping system and nutrient management on yield attributes of maize*

Irrespective of cropping system and nutrient management practices on cob length, cob girth, number of cob $plant^{-1}$, 100-grain weight, number of rows $cob^{-1}$, number of grains $cob^{-1}$ and grain weight $cob^{-1}$ as more in first year than in second year due to more vigorous growth of the crop in second year which was reflected on yield attributes of maize. The presented Table 1 and 2 revealed that the sole crop of maize significantly produced highest yield attributes such as cob length, cob girth, number of cob $plant^{-1}$, 100-grain weight, number of rows $cob^{-1}$, number of grains $cob^{-1}$ and grain weight $cob^{-1}$. Among the cropping system (maize+cowpea) the highest yield attributing was recorded under 2:2 row ratio combination followed by 2:4 row ratio combination (Table 1 and 2). The number of cobs plant$^{-1}$ and number of grains cob$^{-1}$ were influenced significantly when maize was intercropped with cowpea and there was an increasing trend with respect to sole maize 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 cereal crop like maize. The highest number of cob plant-1 were recorded when maize grown as sole crop but when maize grown as intercrop highest number of cob plant-1 were recorded under 2:2 row ratio combination followed by 2:4 row ratio combination (Table 1 and 2). The increment of yield in sole maize is only due to less competition for sunlight, space, water and nutrients (Yilmaz et al., 2008). The number of cob plant$^{-1}$ and number of grains cob$^{-1}$ of maize significantly higher in intercropping maize+blackgram than sole maize, grown both normal row planting and paired row planting (Shivay et al., 2002). Hundred grain weight of maize was significantly influenced due to the practice of its intercropping with others but there was an increasing trend when legumes were intercropped with maize. The legumes when intercropped with maize improve and increased the yield attributes of maize such as cob length, cob girth, number and grain weight, cobs plant$^{-1}$ and 100 grain weight (Sinha, 2017). The yield attributes viz. length and girth of cob, number and weight of

Table 1: Effect of cropping system and integrated nutrient management on yield attributes of maize

| Treatments | | Cob length (cm) | | | Cob girth (cm) | | | Cob plant$^{-1}$ | | | 100- grain weight (g) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cropping system (C) | | YI | YII | Pooled | YI | YII | Pooled | YI | YII | Pooled | YI | YII | Pooled |
| $C_1$ | | 15.45 | 16.18 | 15.54 | 14.36 | 15.38 | 14.84 | 1.47 | 1.56 | 1.53 | 32.70 | 33.74 | 33.02 |
| $C_3$ | | 14.25 | 15.36 | 15.05 | 13.31 | 14.27 | 13.81 | 1.41 | 1.48 | 1.49 | 30.96 | 31.96 | 31.56 |
| $C_4$ | | 13.50 | 14.31 | 13.84 | 12.49 | 14.01 | 13.10 | 1.35 | 1.42 | 1.38 | 29.49 | 30.48 | 29.80 |
| SEm± | | 0.35 | 0.72 | 0.45 | 0.26 | 0.94 | 0.59 | 0.06 | 0.14 | 0.07 | 0.58 | 0.72 | 0.53 |
| CD (*p*=0.05) | | 1.38 | 2.15 | 1.58 | 1.02 | 2.92 | 1.72 | NS | 0.48 | 0.21 | 2.29 | 2.16 | 2.06 |
| Nutrient management (N) | | | | | | | | | | | | | |
| $N_1$ | | 14.11 | 14.84 | 14.07 | 12.94 | 14.14 | 14.37 | 1.38 | 1.44 | 1.39 | 30.19 | 31.42 | 30.37 |
| $N_2$ | | 14.71 | 15.69 | 15.05 | 13.83 | 14.93 | 13.34 | 1.43 | 1.50 | 1.47 | 31.61 | 32.77 | 32.39 |
| $N_3$ | | 15.33 | 16.57 | 15.83 | 14.29 | 15.71 | 15.86 | 1.50 | 1.60 | 1.58 | 33.97 | 34.65 | 34.14 |
| $N_4$ | | 13.45 | 14.03 | 14.30 | 12.49 | 13.43 | 12.08 | 1.32 | 1.40 | 1.40 | 28.42 | 29.40 | 28.93 |
| SEm± | | 0.93 | 0.53 | 0.46 | 0.82 | 0.61 | 0.09 | 0.11 | 0.09 | 0.03 | 1.00 | 0.90 | 0.50 |
| CD (*p*=0.05) | | NS | 1.60 | 1.38 | NS | 2.15 | 0.34 | NS | 0.25 | 0.10 | NS | NS | NS |
| Interaction | | | | | | | | | | | | | |
| $C_1N_1$ | | 15.25 | 15.49 | 14.71 | 13.88 | 14.79 | 14.78 | 1.43 | 1.53 | 1.52 | 31.20 | 32.69 | 31.67 |
| $C_1N_2$ | | 15.83 | 16.80 | 15.15 | 14.78 | 15.95 | 14.74 | 1.50 | 1.57 | 1.50 | 33.43 | 34.59 | 34.41 |
| $C_1N_3$ | | 16.41 | 17.59 | 17.34 | 15.40 | 16.68 | 16.10 | 1.57 | 1.67 | 1.67 | 36.21 | 37.06 | 35.87 |
| $C_1N_4$ | | 14.32 | 14.86 | 14.96 | 13.38 | 14.10 | 13.99 | 1.37 | 1.47 | 1.43 | 29.96 | 30.61 | 30.45 |
| $C_3N_1$ | | 13.96 | 14.86 | 14.38 | 12.91 | 13.74 | 13.34 | 1.37 | 1.43 | 1.42 | 30.53 | 31.64 | 31.14 |
| $C_3N_2$ | | 14.36 | 15.62 | 15.76 | 13.79 | 14.67 | 14.17 | 1.43 | 1.50 | 1.47 | 31.12 | 32.37 | 31.77 |
| $C_3N_3$ | | 15.18 | 16.68 | 15.63 | 14.17 | 15.48 | 15.45 | 1.50 | 1.60 | 1.62 | 33.79 | 34.18 | 34.21 |
| $C_3N_4$ | | 13.48 | 14.27 | 14.43 | 12.40 | 13.18 | 12.23 | 1.33 | 1.40 | 1.44 | 28.40 | 29.66 | 29.21 |
| $C_4N_1$ | | 13.12 | 14.16 | 13.11 | 12.03 | 13.88 | 13.58 | 1.33 | 1.37 | 1.25 | 28.85 | 29.92 | 28.90 |
| $C_4N_2$ | | 13.93 | 14.67 | 14.24 | 12.93 | 14.17 | 12.84 | 1.37 | 1.43 | 1.45 | 30.28 | 31.35 | 30.88 |
| $C_4N_3$ | | 14.39 | 15.44 | 14.51 | 13.31 | 14.96 | 14.75 | 1.43 | 1.53 | 1.46 | 31.92 | 32.71 | 32.32 |
| $C_4N_4$ | | 12.57 | 12.97 | 13.50 | 11.70 | 13.02 | 11.83 | 1.27 | 1.33 | 1.34 | 26.92 | 27.95 | 27.48 |
| C×N | SEm± | 0.71 | 1.07 | 0.23 | 0.52 | 0.64 | 0.17 | 0.11 | 0.09 | 0.05 | 1.17 | 1.44 | 1.49 |
| | CD (*p*=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| N×C | SEm± | 1.43 | 1.21 | 0.69 | 1.26 | 1.45 | 0.87 | 0.17 | 0.17 | 0.10 | 1.61 | 1.53 | 0.91 |
| | CD (*p*=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Table 1: Continue...

| Treatments | Rows cob$^{-1}$ | | | Grain cob$^{-1}$ | | |
|---|---|---|---|---|---|---|
| Cropping system (C) | YI | YII | Pooled | YI | YII | Pooled |
| $C_1$ | 14.20 | 15.23 | 14.72 | 292.38 | 296.16 | 294.27 |
| $C_3$ | 13.19 | 14.56 | 13.88 | 276.97 | 281.66 | 279.31 |
| $C_4$ | 12.25 | 13.58 | 12.92 | 242.77 | 248.23 | 245.50 |
| SEm± | 0.75 | 0.89 | 0.64 | 4.50 | 5.34 | 3.43 |
| CD ($p$=0.05) | NS | 2.66 | 1.95 | 17.60 | 20.88 | 13.39 |
| Nutrient management (N) | | | | | | |
| $N_1$ | 12.93 | 13.91 | 13.42 | 266.57 | 270.18 | 268.37 |
| $N_2$ | 13.53 | 14.88 | 14.20 | 273.86 | 279.37 | 276.62 |
| $N_3$ | 14.46 | 15.80 | 15.13 | 286.01 | 291.47 | 288.74 |
| $N_4$ | 11.93 | 13.24 | 12.59 | 256.39 | 260.38 | 258.38 |
| SEm± | 0.80 | 0.26 | 0.41 | 2.93 | 6.74 | 3.70 |
| CD ($p$=0.05) | NS | 1.01 | 1.23 | 8.70 | 20.05 | 11.01 |
| Interaction | | | | | | |
| $C_1N_1$ | 13.75 | 14.35 | 14.05 | 284.78 | 288.53 | 286.66 |
| $C_1N_2$ | 14.55 | 15.84 | 15.19 | 296.29 | 300.93 | 298.61 |
| $C_1N_3$ | 15.60 | 16.87 | 16.23 | 309.66 | 312.67 | 311.17 |
| $C_1N_4$ | 12.91 | 13.85 | 13.38 | 278.78 | 282.53 | 280.65 |
| $C_3N_1$ | 13.16 | 14.08 | 13.62 | 275.06 | 278.35 | 276.70 |
| $C_3N_2$ | 13.69 | 14.84 | 14.27 | 279.60 | 283.72 | 281.66 |
| $C_3N_3$ | 14.10 | 15.76 | 14.93 | 291.32 | 298.65 | 294.99 |
| $C_3N_4$ | 11.81 | 13.56 | 12.69 | 261.91 | 265.90 | 263.90 |
| $C_4N_1$ | 11.89 | 13.28 | 12.59 | 239.86 | 243.65 | 241.75 |
| $C_4N_2$ | 12.35 | 13.95 | 13.15 | 245.70 | 253.46 | 249.58 |
| $C_4N_3$ | 13.68 | 14.77 | 14.22 | 257.05 | 263.08 | 260.06 |
| $C_4N_4$ | 11.08 | 12.33 | 11.71 | 228.49 | 232.73 | 230.61 |
| C×N SEm± | 1.49 | 0.51 | 0.81 | 9.02 | 10.69 | 6.86 |
| C×N CD ($p$=0.05) | NS | NS | NS | NS | NS | NS |
| N×C SEm± | 1.41 | 1.37 | 1.05 | 6.29 | 11.45 | 6.53 |
| N×C CD ($p$=0.05) | NS | NS | NS | NS | NS | NS |

YI: 2014; YII: 2015; $C_1$: Sole maize; $C_3$: Maize+cowpea (2:2); $C_4$: Maize+cowpea (2:4); $N_1$: 100% RDF 80:40:40 kg ha$^{-1}$ of N: $P_2O_5$: $K_2O$; $N_2$: 100% RDF+Phosphate solubilising bacteria (PSB)+*Azotobacter* $N_3$: 75% RDF+PSB+*Azotobacter*+vermicompos t (VC) @ 5.0 t ha$^{-1}$; $N_4$: 50% RDF+PSB+*Azotobecter*+50% vermicompost @ 2.5 t ha$^{-1}$

grains cob$^{-1}$, cob plant$^{-1}$, number of rows cob$^{-1}$ and 100 grain weight were also increased by intercropping legumes (Table 1 and 2). The influence of integrated nutrient management on yield attributing characters such as number of rows cob$^{-1}$, 100-seed weight, number of seeds cob$^{-1}$, length and cob girth, grain weight cob$^{-1}$ and number of cob plant$^{-1}$ (Table 1 and 2) was recorded highest under treatment receiving 75% RDF in combination with PSB+*Azotobacter*+vermicompost @ 5.0 t ha$^{-1}$ ($N_3$) when maize was grown as sole crop but when maize grown as intercrop highest number of cob plant$^{-1}$ were recorded under 2:2 row ratio combination followed by 2:4 row ratio combination. It might have been owing to better utilization of resources, availability and absorption of nutrient by crop. This results also conformity with the findings of Rana et al., 2001; Kumar et al., 2017.

### *3.2. Yield components of associated intercrops*

Yield attributes such as number of pods plant$^{-1}$, number of seeds pod$^{-1}$ and 1000-seed weight was significantly reduced due to intercropping system (Table 3). The highest number of pods plant$^{-1}$ (27.87 and 30.76), number of seeds pod$^{-1}$ (21.12 and 23.11) and 1000-seed weight (130.72 and 133.15) was

Table 2: Effect of cropping system and integrated nutrient management on yield attributes and yield of maize

| Treatments | | Grain weight $cob^{-1}$ | | | Grain yield (kg $ha^{-1}$) | | | Stover yield (kg $ha^{-1}$) | | | Harvest index (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cropping system (C) | | YI | YII | Pooled | YI | YII | Pooled | YI | YII | Pooled | YI | YII | Pooled |
| $C_1$ | | 75.11 | 78.04 | 76.64 | 3771 | 4054 | 3913 | 6437 | 6693 | 6565 | 36.96 | 37.65 | 37.31 |
| $C_3$ | | 71.49 | 74.44 | 73.24 | 3119 | 3378 | 3249 | 5600 | 5812 | 5707 | 35.68 | 36.71 | 36.19 |
| $C_4$ | | 68.97 | 71.59 | 70.07 | 2631 | 2890 | 2761 | 5088 | 5270 | 5179 | 33.97 | 35.32 | 34.65 |
| SEm± | | 1.74 | 1.73 | 0.79 | 1.19 | 1.33 | 0.66 | 1.15 | 1.09 | 1.15 | 0.64 | 0.63 | 0.43 |
| CD (*p*=0.05) | | NS | 5.14 | 3.09 | 3.53 | 3.95 | 2.58 | 4.51 | 4.28 | 3.48 | NS | NS | 1.68 |
| Nutrient management (N) | | | | | | | | | | | | | |
| $N_1$ | | 70.59 | 73.58 | 72.41 | 3036 | 3340 | 3188 | 5586 | 5807 | 5696 | 35.04 | 36.40 | 35.73 |
| $N_2$ | | 73.14 | 75.71 | 74.88 | 3280 | 3507 | 3394 | 5811 | 6009 | 5910 | 35.95 | 36.70 | 36.33 |
| $N_3$ | | 76.58 | 79.13 | 78.19 | 3536 | 3830 | 3684 | 6151 | 6263 | 6207 | 36.43 | 37.84 | 37.14 |
| $N_4$ | | 67.11 | 70.34 | 67.79 | 2842 | 3086 | 2964 | 5285 | 5622 | 5454 | 34.73 | 35.29 | 35.01 |
| SEm± | | 1.49 | 0.61 | 0.87 | 0.74 | 0.63 | 0.69 | 1.42 | 1.28 | 0.56 | 0.99 | 0.99 | 0.78 |
| CD (*p*=0.05) | | 4.43 | 2.38 | 2.57 | 2.89 | 2.46 | 2.05 | 4.24 | 3.79 | 2.21 | NS | NS | NS |
| Interaction | | | | | | | | | | | | | |
| $C_1N_1$ | | 73.07 | 76.10 | 73.60 | 3645 | 3965 | 3805 | 6330 | 6566 | 6448 | 36.61 | 37.63 | 37.12 |
| $C_1N_2$ | | 76.84 | 78.54 | 78.82 | 3877 | 4112 | 3995 | 6539 | 6759 | 6649 | 37.23 | 37.77 | 37.50 |
| $C_1N_3$ | | 81.20 | 84.31 | 84.53 | 4087 | 4405 | 4246 | 6993 | 7071 | 7032 | 36.89 | 38.32 | 37.61 |
| $C_1N_4$ | | 69.34 | 73.21 | 69.62 | 3475 | 3733 | 3604 | 5884 | 6377 | 6131 | 37.11 | 36.88 | 37.00 |
| $C_3N_1$ | | 70.62 | 73.05 | 74.08 | 2970 | 3269 | 3120 | 5489 | 5723 | 5606 | 35.08 | 36.44 | 35.76 |
| $C_3N_2$ | | 72.13 | 75.87 | 74.06 | 3202 | 3466 | 3334 | 5701 | 5907 | 5804 | 35.97 | 36.93 | 36.45 |
| $C_3N_3$ | | 76.19 | 78.59 | 77.12 | 3546 | 3800 | 3673 | 5988 | 6115 | 6051 | 37.16 | 38.28 | 37.72 |
| $C_3N_4$ | | 67.02 | 70.23 | 67.70 | 2758 | 2980 | 2869 | 5226 | 5505 | 5366 | 34.52 | 35.18 | 34.85 |
| $C_4N_1$ | | 68.11 | 71.57 | 69.54 | 2493 | 2785 | 2639 | 4941 | 5130 | 5036 | 33.44 | 35.15 | 34.29 |
| $C_4N_2$ | | 70.46 | 72.72 | 71.77 | 2762 | 2945 | 2854 | 5192 | 5363 | 5278 | 34.67 | 35.40 | 35.04 |
| $C_4N_3$ | | 72.35 | 74.48 | 72.92 | 2976 | 3285 | 3130 | 5473 | 5604 | 5538 | 35.22 | 36.94 | 36.08 |
| $C_4N_4$ | | 64.97 | 67.59 | 66.05 | 2293 | 2546 | 2420 | 4748 | 4986 | 4867 | 32.55 | 33.82 | 33.19 |
| C×N | SEm± | 3.48 | 1.22 | 1.58 | 1.47 | 1.26 | 1.32 | 2.31 | 2.19 | 1.13 | 1.27 | 1.26 | 0.86 |
| | CD (*p*=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| N×C | SEm± | 2.83 | 2.66 | 1.52 | 1.92 | 2.09 | 1.23 | 2.43 | 2.21 | 1.82 | 1.62 | 1.62 | 1.25 |
| | CD (*p*=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

YI: 2014; YII: 2015; $C_1$: Sole maize; $C_3$: Maize+cowpea (2:2); $C_4$: Maize+cowpea (2:4); $N_1$: 100% RDF 80:40:40 kg $ha^{-1}$ of N: $P_2O_5$: $K_2O$; $N_2$: 100% RDF+Phosphate solubilising bacteria (PSB)+*Azotobacter*; $N_3$: 75% RDF+PSB+*Azotobacter*+vermicompo st (VC) @ 5.0 t $ha^{-1}$; $N_4$: 50% RDF+PSB+*Azotobecter*+50% vermicompost @ 2.5 t $ha^{-1}$

recorded under sole crop of cowpea. However, intercropping system 2:4 row ratio combination recorded the highest number of pods $plant^{-1}$ (25.32 and 27.44), number of seeds $pod^{-1}$ (19.24 and 20.87) and 1000-seed weight (128.92 and 129.87) compared to the 2:2 row ratio combination. This might be due to the cowpea intercrop with maize were shorter in height and could utilize lower percentage of incoming solar radiation which are adversely affected in 2:2 row ratio combination. The test weights of different seeds were not significantly affected due to intercropping. However, it was evident that a decreasing trend of 1000-seed weight was noticed in 2:4 row ratio followed by 2:2 row ratio combination compared to the sole crop (Table 3). Lower number of pods $plant^{-1}$ and seeds $pod^{-1}$ as compared to monoculture was recorded under intercropping system (Sorushe et al., 2000) and cowpea and blackgram intercrop with maize in paired row ratio combination significantly increased the yield attributes (Naresh et al., 2014).

Integrated nutrient management practices significantly influence the yield attributes such as pods plant$^{-1}$, seeds pod$^{-1}$ and test weight (Table 3). Cowpea grown as sole crop of produced the maximum number of pods plant$^{-1}$ (28.72 and 31.25), seeds pod$^{-1}$ (22.49 and 24.48) and test weight (133.31 and 133.95) under treatment received 75% RDF+PSB+*Azotobacter*+vermicompost @ 5.0 t ha$^{-1}$ ($N_3$). When cowpea intercrop with maize the highest yield attributes was recorded under the 2:4 row ratio combination followed by 2:2 row ratio combination.This might be due to the proper utilization of space, nutrient, moisture and light or shading effect by main crop. The application of 75% recommended dose of fertilizer to maize and 50% to soybean significantly increased yields, over 50% RDF in maize and no fertilizer in soybeanas reported by Meena et al. (2006).

### *3.3. Effect of cropping system and nutrient management on grain yield, stover yield and harvest index of maize*

The greater grain and stover yield of maize produced in the sole crops compared to the intercropping system. The highest grain yield and stover yield were recorded under sole maize compared to the intercropping situation this was due to the more number of plant population per unit area. But when maize intercrop with cowpea the highest grain and stover yield were recorded under 2:2 row ratio combination followed by

Table 3: Effect of cropping system and nutrient management on yield attributes and yield of cowpea

| Treatments | | Pods plant$^{-1}$ | | | Seeds pods$^{-1}$ | | | 1000- seed weight (g) | | | Seeds yield (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cropping system (C) | | YI | YII | Pooled | YI | YII | Pooled | YI | YII | Pooled | YI | YII | Pooled |
| $C_2$ | | 27.87 | 30.76 | 29.17 | 21.12 | 23.11 | 22.11 | 130.72 | 133.15 | 131.94 | 938 | 943 | 3913 |
| $C_3$ | | 23.70 | 25.44 | 24.57 | 18.25 | 19.52 | 18.89 | 127.17 | 128.01 | 127.59 | 663 | 668 | 3249 |
| $C_4$ | | 25.32 | 27.44 | 26.39 | 19.24 | 20.87 | 20.56 | 128.92 | 129.87 | 129.39 | 761 | 764 | 2761 |
| SEm± | | 1.24 | 1.03 | 0.54 | 0.47 | 0.90 | 0.93 | 0.95 | 1.31 | 0.59 | 0.12 | 0.09 | 0.66 |
| CD (*p*=0.05) | | 3.79 | 4.03 | 2.09 | 1.85 | 3.71 | 2.85 | 3.73 | 3.94 | 2.31 | 0.45 | 0.29 | 2.58 |
| Nutrient management (N) | | | | | | | | | | | | | |
| $N_1$ | | 24.83 | 26.82 | 25.83 | 18.67 | 20.30 | 19.48 | 127.69 | 129.31 | 128.50 | 778 | 778 | 3188 |
| $N_2$ | | 26.83 | 29.50 | 28.16 | 20.26 | 22.11 | 21.19 | 129.98 | 131.28 | 130.63 | 802 | 809 | 3394 |
| $N_3$ | | 28.72 | 31.25 | 30.01 | 22.49 | 24.48 | 23.49 | 133.31 | 133.95 | 133.63 | 833 | 837 | 3684 |
| $N_4$ | | 22.13 | 23.59 | 22.86 | 16.72 | 17.77 | 17.25 | 124.77 | 126.82 | 125.79 | 737 | 742 | 2964 |
| SEm± | | 0.47 | 1.05 | 0.70 | 1.99 | 1.23 | 0.52 | 0.98 | 0.45 | 0.75 | 0.08 | 0.07 | 0.69 |
| CD (*p*=0.05) | | 1.85 | 3.13 | 2.09 | NS | 3.66 | 2.14 | 2.91 | 1.78 | 2.24 | 0.24 | 0.24 | 2.05 |
| Interaction | | | | | | | | | | | | | |
| $C_2N_1$ | | 26.85 | 29.77 | 28.31 | 20.02 | 22.03 | 21.02 | 129.99 | 132.62 | 131.31 | 936 | 938 | 3805 |
| $C_2N_2$ | | 28.96 | 31.73 | 30.34 | 22.02 | 24.21 | 23.12 | 131.12 | 133.69 | 132.41 | 950 | 960 | 3995 |
| $C_2N_3$ | | 30.91 | 33.51 | 32.21 | 24.05 | 26.53 | 25.29 | 135.87 | 136.65 | 136.26 | 966 | 969 | 4246 |
| $C_2N_4$ | | 24.75 | 26.90 | 25.82 | 18.39 | 19.65 | 19.02 | 125.90 | 129.62 | 127.76 | 901 | 905 | 3604 |
| $C_3N_1$ | | 22.81 | 23.97 | 23.39 | 17.21 | 18.51 | 17.86 | 125.87 | 126.62 | 126.25 | 657 | 660 | 3120 |
| $C_3N_2$ | | 24.86 | 27.40 | 26.13 | 19.02 | 20.66 | 19.84 | 128.91 | 129.40 | 129.16 | 673 | 677 | 3334 |
| $C_3N_3$ | | 26.80 | 29.20 | 28.00 | 21.42 | 22.79 | 22.11 | 131.24 | 132.06 | 131.65 | 707 | 713 | 3673 |
| $C_3N_4$ | | 20.33 | 21.20 | 20.77 | 15.36 | 16.13 | 15.74 | 122.66 | 123.97 | 123.31 | 616 | 621 | 2869 |
| $C_4N_1$ | | 24.84 | 26.72 | 25.78 | 18.78 | 20.36 | 19.57 | 127.22 | 128.69 | 127.96 | 741 | 736 | 2639 |
| $C_4N_2$ | | 26.68 | 29.34 | 28.01 | 19.74 | 21.46 | 20.60 | 129.92 | 130.75 | 130.33 | 784 | 789 | 2854 |
| $C_4N_3$ | | 28.47 | 31.03 | 29.75 | 22.02 | 24.13 | 23.07 | 132.80 | 133.15 | 132.98 | 825 | 829 | 3130 |
| $C_4N_4$ | | 21.31 | 22.66 | 21.99 | 16.42 | 17.53 | 16.98 | 125.75 | 126.87 | 126.31 | 695 | 703 | 2420 |
| C×N | SEm± | 2.15 | 1.07 | 1.07 | 2.15 | 2.13 | 1.03 | 1.69 | 2.27 | 1.12 | 0.23 | 0.13 | 1.32 |
| | CD (*p*=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| N×C | SEm± | 1.92 | 1.18 | 1.18 | 1.72 | 2.06 | 1.48 | 1.75 | 2.02 | 1.26 | 0.17 | 0.15 | 1.23 |
| | CD (*p*=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Table 3: Continue...

| Treatments | | Stem yield (kg$^{-1}$) | | | Harvest index (%) | | |
|---|---|---|---|---|---|---|---|
| Cropping system (C) | | YI | YII | Pooled | YI | YII | Pooled |
| $C_2$ | | 1421 | 1435 | 6565 | 40.09 | 39.97 | 37.31 |
| $C_3$ | | 1003 | 1010 | 5707 | 39.79 | 39.81 | 36.19 |
| $C_4$ | | 1202 | 1211 | 5179 | 38.91 | 38.91 | 34.65 |
| SEm± | | 0.83 | 0.41 | 1.15 | 1.36 | 0.75 | 0.43 |
| CD (*p*=0.05) | | NS | 1.60 | 3.48 | NS | NS | 1.68 |
| Nutrient Management (N) | | | | | | | |
| $N_1$ | | 1157 | 1173 | 5696 | 40.19 | 39.95 | 35.73 |
| $N_2$ | | 1238 | 1236 | 5910 | 39.46 | 39.67 | 36.33 |
| $N_3$ | | 1349 | 1358 | 6207 | 38.50 | 38.54 | 37.14 |
| $N_4$ | | 1091 | 1108 | 5454 | 40.22 | 40.08 | 35.01 |
| SEm± | | 0.19 | 0.47 | 0.56 | 0.40 | 0.87 | 0.78 |
| CD (*p*=0.05) | | 0.58 | 1.40 | 2.21 | 1.21 | NS | NS |
| Interaction | | | | | | | |
| $C_2N_1$ | | 1336 | 1371 | 6448 | 41.40 | 40.81 | 37.12 |
| $C_2N_2$ | | 1482 | 1460 | 6649 | 39.21 | 39.80 | 37.50 |
| $C_2N_3$ | | 1633 | 1647 | 7032 | 37.29 | 37.29 | 37.61 |
| $C_2N_4$ | | 1234 | 1264 | 6131 | 42.45 | 41.96 | 37.00 |
| $C_3N_1$ | | 992 | 997 | 5606 | 39.82 | 39.82 | 35.76 |
| $C_3N_2$ | | 1004 | 1015 | 5804 | 40.16 | 40.02 | 36.45 |
| $C_3N_3$ | | 1041 | 1047 | 6051 | 40.47 | 40.63 | 37.72 |
| $C_3N_4$ | | 975 | 980 | 5366 | 38.70 | 38.76 | 34.85 |
| $C_4N_1$ | | 1143 | 1152 | 5036 | 39.35 | 39.23 | 34.29 |
| $C_4N_2$ | | 1228 | 1233 | 5278 | 39.03 | 39.18 | 35.04 |
| $C_4N_3$ | | 1372 | 1381 | 5538 | 37.75 | 37.71 | 36.08 |
| $C_4N_4$ | | 1065 | 1080 | 4867 | 39.51 | 39.50 | 33.19 |
| C×N | SEm± | 1.67 | 0.82 | 1.13 | 2.72 | 1.51 | 0.86 |
| | CD (*p*=0.05) | NS | NS | NS | NS | NS | NS |
| N×C | SEm± | 0.88 | 0.81 | 1.82 | 1.49 | 1.52 | 1.25 |
| | CD (*p*=0.05) | NS | NS | NS | NS | NS | NS |

YI=2014; YII= 2015, $C_2$: Sole cowpea; $C_3$: Maize+cowpea (2:2); $C_4$: Maize+cowpea (2:4); $N_1$: 100% RDF 80:40:40 kg ha$^{-1}$ of N: $P_2O_5$: $K_2O$; $N_2$: 100% RDF+Phosphate solubilising bacteria (PSB)+*Azotobacter*; $N_3$: 75% RDF+PSB+*Azotobacter*+vermicompost (VC) @ 5.0 t ha$^{-1}$; N4:50% RDF+PSB+*Azotobecter*+50% vermicompost @ 2.5t ha$^{-1}$

2:4 row ratio combination (Table 2). Grain yield and stover yield of maize was significantly higher in case of sole crop of maize compared to intercropping systems (maize with soybean and groundnut intercrops) (Mandal et al., 2014) and maize-soybean intercropping system (Himmatrao et al., 2014). The yield advantage of maize in intercropping systems with legumes probably occurred from the difference in the timing ofutilization of resources by crop from soil layers, especially during peak vegetative and reproductive stages of growth, thus resulting in both temporal and spatial complementarities. Also, the increase in grain yield of maize might be resulted from maize-legume association due to symbiotic nitrogen fixation by legumes and current transfer of nitrogen to the associated maize plants (Table 2). Intercropping of maize with cowpea had significant effects on grain yield, stover yield and improved soil fertility as reported by Dahmardeh et al., (2010). Maize-legumes intercropping system, the combined intercrop grain yields (maize + cowpea or groundnut) were smaller than that of sole maize (Kermah et al., 2017).

Integrated nutrient management practices on grain and stover yield of maize significantly increased in treatment receiving 75% RDF+PSB+*Azotobacter*+vermicompost @ 5.0 t ha$^{-1}$ ($N_3$) compared to the other treatments when maize grown as sole crop but when maize grown as intercrop highest grain and stover yield were recorded under 2:2 row ratio combination followed by 2:4 row ratio combination (Table 2). This was due to enhanced yield attributes of maize, available nutrients and improves soil fertility. But Ojiem et al. (2014) in Western Kenya who observed a consistent decrease in maize and legume grain yields in response to decreases in soil fertility. The application of 100% recommended dose of fertilizers to intercrop increased significantly maize and lentil yield (Misra et al., 2001) and applied 100% RDF in conjunction with vermicompost and biofertiliser produced greater grain yield (Satyajeet et al., 2007)

Harvest index in intercropping systems, highest was recorded under sole crop of maize but when maize intercropped with cowpea, higher harvest index of maize was recorded under 2:2 row ratio combination followed by 2:4 row ratio combination (Table 2). This might be due to sole crop of maize more harvest index reflects the partitioning of photosynthetic between the grain and the vegetative plant, and improvement in the harvest index emphasizes the importance of carbon allocation for grain production. Among the integrated nutrient management practices, highest harvest index of maize was recorded in 75% RDF+PSB+*Azotobacter*+vermicompost @ 5.0 t ha$^{-1}$ ($N_3$). The lowest harvest index of maize was recorded under 50% RDF+PSB+*Azotobacter*+50% vermicompost 2.5 t ha$^{-1}$ ($N_4$) (Table 2). This might due to the increased growth of crop which resulted in more absorption and translocation of these nutrients to the grain and stover.

*3.4. Yield of associated intercrops*

Cowpea yield was reduced due to intercrop with maize. However, sole crop of cowpea recorded the highest seed yield (938 and 943 kg ha$^{-1}$), stem yield (1421 and 1435 kg ha$^{-1}$) and harvest index (40.09 and 39.97%). When cowpea intercrop with maize the 2:4 row ratio combinations slightly higher seed yield (761 and 764 kg ha$^{-1}$), stem yield (1202 and 1211 kg ha$^{-1}$) and harvest index (38.91 and 38.91%) than 2:2 row ratio combination (Table 3). This might be due to the 2:4 row ratio combination receipt of higher amount of solar radiation. The main reason for reduction of yield might be due to the tall growing maize plants shaded the leguminous crops and probably due to the receipt of lower amount of incoming solar radiation which affected the rate of photosynthesis and thereby translocation of photosynthesis from source to sink. Decrease in yield of cowpea also occurred due to intercropping with maize as reported by Patra et al. (2000).

The integrated nutrient management practices, the highest seed yield (833 and 837 kg ha$^{-1}$) and stem yield (1349 and 1358 kg ha$^{-1}$) was recorded under treatment which received 75% RDF+PSB+*Azotobacter*+vermicompost (VC) @ 5.0 t ha$^{-1}$ ($N_3$) but highest harvest index (40.22 and 40.08%) was recorded under 50% RDF+PSB+*Azotobacter*+50% vermicompost @ 2.5 t ha$^{-1}$ ($N_4$) when cowpea grown as sole crop but when cowpea intercrop with maize highest seed and stem yield were recorded under 2:4 row ratio combination followed by 2:2 row ratio combination (Table 3). This might be owing to the availability, utilization and absorption of applied nutrient was attributable to higher seed and stems production with better utilization of nutrient and improves root growth which enhanced the yield of seed and stem. This result also conformity with the findings of Anitha et al., 2001a; Kolawole et al., 2000; Sangakara et al., 2001.

*3.5. Effect of cropping system and nutrient management on competition indices*

Aggressivity values were positive (+ve) in maize which obviously indicated that maize was the dominant crop, whereas the associated intercrops appeared to be the dominated ones having negative (-ve) values (Table 4). From the two different row ratio combination, the higher values of aggressivity was recorded under 2:4 row ratio combination (Table 4). However, Alexander and Genter (1962) was reported from other instances that increase in dry matter occurred when corn was released from self competition and bordered by the competitive crop. Maize intercropped with cowpea and rice bean both (in row proportion 2:1) was found to be a compatible intercropping system with lower values of aggressivity (Sharma and Singh, 2008) and maize-based intercropping systems were more remunerative compared to the sole maize (Sawargaonkar et al., 2008).

Competitive ratio (CR) for maize was always higher compared with the associated intercrops and higher competitive ratio of maize was observed at 2: 2 proportion of intercropping than 2: 4 proportions (Table 4). This might be owing to maize appeared to be more competitive and the subsidiary intercrops were found to be less competitive with respect to utilization of available resources. This indicated that maize was more competitive than cowpea in all mix-proportions. Competitive ratio was higher in maize and the CR value increased with an increased A value of maize (Takim, 2012). However, increased in competitive ability of maize did not necessarily mean a decrease in competitive ability of legumes. Maize was found to be most competitive one when grown with cowpea at lower level of fertility. In 2: 2 row ratio combinations were superior to grain yield and parameters related to competitive ability than 2:4 row ratio combinations (Table 4). Similar results also corroborated with findings of Padhi and Pangrahi, 2006.

The values of relative crowding co-efficient of maize were found to be greater than unity indicating that species produced more yield than expected. However, the actual yield of cowpea was less than expected in two different row ratios (2:2 and 2:4). It was due to the less plant population and shading effect compared to the monocrop and different level of fertilizers. All the intercropping systems were found to be

Table 4: Effect of cropping system and nutrient management on aggressivity, competition ratio and relative crowding coefficient

| Treat-ments | Aggressivity | | | | Competition ratio | | | | Relative crowding coefficient | | | | LER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aab | | Aba | | CRa | | CRb | | Kab | | Kba | | | |
| | YI | YII | YI | YII | YI | YII | YI | YII | YI | YII | YI | YII | YI | YII |
| Maize+cowpea (2:2) | | | | | | | | | | | | | | |
| $C_3N_1$ | 0.226 | 0.242 | -0.226 | -0.242 | 1.161 | 1.172 | 0.862 | 0.853 | 4.40 | 4.70 | 2.36 | 2.37 | 1.52 | 1.53 |
| $C_3N_2$ | 0.234 | 0.263 | -0.234 | -0.263 | 1.165 | 1.185 | 0.858 | 0.844 | 4.75 | 5.36 | 2.44 | 2.46 | 1.53 | 1.55 |
| $C_3N_3$ | 0.270 | 0.256 | -0.270 | -0.256 | 1.184 | 1.174 | 0.845 | 0.852 | 6.56 | 6.29 | 2.74 | 2.77 | 1.60 | 1.59 |
| $C_3N_4$ | 0.220 | 0.223 | -0.220 | -0.223 | 1.161 | 1.162 | 0.861 | 0.861 | 3.85 | 3.96 | 2.16 | 2.20 | 1.48 | 1.48 |
| Maize+cowpea (2:4) | | | | | | | | | | | | | | |
| $C_4N_1$ | 1.799 | 1.738 | -1.799 | -1.738 | 0.432 | 0.447 | 0.579 | 0.559 | 1.08 | 1.18 | 1.90 | 1.83 | 1.48 | 1.49 |
| $C_4N_2$ | 1.875 | 1.879 | -1.875 | -1.879 | 0.432 | 0.433 | 0.579 | 0.578 | 1.24 | 1.26 | 2.36 | 2.40 | 1.54 | 1.54 |
| $C_4N_3$ | 1.963 | 1.928 | -1.963 | -1.928 | 0.426 | 0.436 | 0.587 | 0.573 | 1.34 | 1.47 | 2.94 | 2.95 | 1.58 | 1.61 |
| $C_4N_4$ | 1.768 | 1.745 | -1.768 | -1.745 | 0.427 | 0.439 | 0.585 | 0.570 | 0.97 | 1.07 | 1.69 | 1.74 | 1.43 | 1.46 |

YI: 2014; YII: 2015, $C_2$: Sole cowpea; $C_3$: Maize+cowpea (2:2); $C_4$: Maize+cowpea (2:4); $N_1$: 100% RDF 80:40:40 kg ha$^{-1}$ of N: $P_2O_5$: $K_2O$; $N_2$: 100% RDF+Phosphate solubilising bacteria (PSB)+*Azotobacter*; $N_3$: 75% RDF+PSB+*Azotobacter*+vermicompo st (VC) @ 5.0 t ha$^{-1}$; N4:50% RDF+PSB+*Azotobecter*+50% vermicompost @ 2.5 t ha$^{-1}$

advantageous as the product values (k) were always greater than unity in 2:2 row ratio combination than 2:4 row ratio combination (Table 4). This result is also conformity with the findings of Dhima et al. (2007) in cereal-vetch intercropping.

The LER values in different intercropping systems were always greater than unity indicating yield advantages from intercropping systems than sole cropping (Table 4). The higher LER values was observed under 2:2 row ratio combination (C3N3) in first year but in second year the highest LER values were recorded under C4N3 i.e. 2:4 row ratio combination indicating a considerable increase in resource use efficiency at a higher dose of fertilizers (Table 4). This was due to the better utilization of special and temporal utilization of land and natural resources in intercropping with additional advantage of cowpea and higher market price of cowpea, compared to sole cropping of maize and cowpea. Our results agree with the findings of other authors such as Kermaha, 2017; Himmatrao et al., 2014; Sharma et al., 2006; Sharma and Behera, 2009 and Meena et al., 2006.

Competition index were recorded highest under 2:4 row ratio combination compared to 2:2 row ratio combination. This might be due to more number of maize plants per unit area and lesser competition for space and nutrients under 2:2 row ratio combination compared to 2:4 row ratio combination which increased the yield of maize under this system (Table 5).

Values of Area Time Equivalent Ratio (ATER) were also greater than unity in all the cases of intercropping systems. In 2:2 maize-cowpea row ratio combination of sowing recorded highest ATER values which appeared to be advantageous and indicated higher productivity comparison to monoculture (Table 5). This was due to the greater resource use and resource complementarily when the species were grown together. Kheroar and Patra (2014) reported that maize + blackgram (2:2) intercropping recorded the highest ATER value which was achieved due to development of special complementarily.

Land equivalent co-efficient values were always recorded to be greater than 0.25 which indicated yield advantages in maize – legume intercropping situations in both the proportions of intercropping (2:2 and 2:4). The highest land equivalent co-efficient was recorded under 2:2 row ratio combination followed by 2:4 row ratio combination due to better spatial complementarily (Table 5). However, Mohan et al. (2005) the land equivalent co-efficient were higher in maize+legume in 1:2 proportion than in 1:1 proportion which was in close proximity with the present investigation.

Maize equivalent yield was recorded to be higher in all of the cases of intercropping with respect to pure stand yield of maize. In maize-legume intercropping, maize yield and extra yield of legumes helped in increasing maize equivalent yield. Maximum maize-equivalent yield was recorded under 2:2 row ratio combination followed by 2:4 row ratio combination (Table 5). It might be due to better utilization of resources and balanced competition between components crops. Maize equivalent yield was significantly higher in intercrops than the sole maize crop was also reported by Choudhary et al. (2014). Various yield attributes of maize were superior under sole cropping, followed by maize + cowpea intercropping system. Intercropping gave bonus yield, (Pathak and Singh, 2008) which increased maize equivalent yield over their respective monoculture (Choudhary et al., 2014).

Intercropping system showed higher monetary advantage

Table 5: Effect of cropping system and nutrient management on land equivalent ratio, monetary advantage and area time equivalent ratio

| Treat-ments | LEC | | ATER | | Competition index | | Monetary advantage (Rs) | | Maize equivalent yield | | Combined yield (kg $ha^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | YI | YII | YI | YII | YI | YII | YI | YII | YI | YII | YI | YII |
| Maize+cowpea (2:2) | | | | | | | | | | | | |
| $C_3N_1$ | 0.572 | 0.580 | 1.60 | 1.62 | 1.740 | 1.491 | 1235 | 1357 | 5764.77 | 5956.46 | 3627 | 3929 |
| $C_3N_2$ | 0.586 | 0.600 | 1.63 | 1.65 | 1.501 | 1.247 | 1349 | 1477 | 6068.27 | 6226.08 | 3875 | 4143 |
| $C_3N_3$ | 0.636 | 0.634 | 1.69 | 1.69 | 0.963 | 0.929 | 1589 | 1687 | 6556.99 | 6702.80 | 4253 | 4513 |
| $C_3N_4$ | 0.542 | 0.548 | 1.58 | 1.58 | 2.133 | 1.916 | 1089 | 1176 | 5377.69 | 5511.43 | 3373 | 3601 |
| Maize+cowpea (2:4) | | | | | | | | | | | | |
| $C_4N_1$ | 0.541 | 0.552 | 1.54 | 1.57 | 2.473 | 2.098 | 1041 | 1154 | 5644.73 | 5785.53 | 3234 | 3521 |
| $C_4N_2$ | 0.588 | 0.593 | 1.61 | 1.61 | 1.730 | 1.509 | 1238 | 1315 | 6096.58 | 6156.55 | 3546 | 3733 |
| $C_4N_3$ | 0.622 | 0.638 | 1.65 | 1.67 | 1.282 | 1.081 | 1368 | 1543 | 6488.06 | 6662.61 | 3801 | 4114 |
| $C_4N_4$ | 0.510 | 0.530 | 1.49 | 1.54 | 3.044 | 2.505 | 901 | 1022 | 5252.30 | 5409.72 | 2988 | 3249 |

YI: 2014; YII: 2015, $C_2$: Sole cowpea; $C_3$: Maize+cowpea (2:2); $C_4$: Maize+cowpea (2:4); $N_1$: 100% RDF 80:40:40 kg $ha^{-1}$ of N: $P_2O_5$: $K_2O$; $N_2$: 100% RDF+Phosphate solubilising bacteria (PSB)+*Azotobacter*; $N_3$: 75% RDF+PSB+*Azotobacter*+vermicompo st (VC) @ 5.0 t $ha^{-1}$; N4:50% RDF+PSB+*Azotobecter*+50% vermicompost @ 2.5 t $ha^{-1}$

as compared to sole crop. In 2:2 proportion of intercropping fetched higher monetary advantage as compared to 2: 4 row ratio combinations of maize+cowpea intercropping system. 2:4 proportion of sowing indicated less interspecific competition than 2:2 row ratio combinations (Table 5). Intercropping systems in 2:2 and 2:4 row ratios showed higher monetary advantage as compared to sole crops. This result also corroborated with the findings of Kumar et al. (2005); Singh and Singh (2001)

Combined yield was always higher in maize-legume association as compared to sole maize which might be attributed due to the inclusion of yield of maize with some yield of legumes (Table 5). In maize- legume association maize was benefitted by nitrogen fixation of intercropped legumes. Total yield increase in maize-legume intercropping was also reported by Ghanbari et al., 2010 and Dahmardeh, 2010.

## 4. Conclusion

Maize grown as sole crop along with 75% RDF+PSB+*Azotobacter*+vermicompost @ 5.0 t $ha^{-1}$ gave overall performance but to sustain soil fertility as well cowpea intercropping with maize could be better opinion. Two rows of maize and four rows of cowpea (2:4) in combination with 75% RDF+PSB+*Azotobacter*+vermicompost @ 5.0 t $ha^{-1}$ would be the best combination for yield and competition indices. Intercropping of cowpea and maize can be suggested as a productive, remunerative and biologically sustainable intercropping system under pre kharif season in Tarai region of West Bengal.

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