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Growth and Yield Responses of Cowpea (*Vigna unguiculata* L.) as Influenced by Crop Geometry and Nutrient Management Practices

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ABSTRACT

Background: Inclusion of legume with cereal as an intercrop ensure crop nutrition and enhanced soil quality. Combine application of organic manure with inorganic fertilizer minimizes the soil hazard and improves crop productivity in a significant manner.

Methods: The experiment on *Kharif* maize +cowpea intercropping system was carried out at 'Jaguli Instructional Farm' of Bidhan Chandra Krishi Viswavidyalaya, Nadia, under the New Alluvial Zone of West Bengal in 2019-2020 to investigate the influence of crop geometry and nutrient management practices on growth and yield responses of legume (cowpea). The experiment was laid out with a split-plot design. The main plot had five crop geometry and a sub plot comprised five nutrient management practices, which were replicated thrice.

Result: From the pooled data of two years experiment, the intercropping system of 1M:1C (Maize: Cowpea) (C3) perform better in respect of growth attributes, *viz.,* leaves plant^{-1}, LAI, branches plant^{-1} and CGR; yield reflecting attributes *viz.,* pods plant^{-1}, pod length, pod and forage yield of cowpea (1.30 and 5.49 t ha^{-1}) and crop (maize) equivalent yield of cowpea (1.76 t ha^{-1}) although the maximum values were attained from sole cowpea treatment (C2). Nutrient management practices with the application of 75% N as chemical + 25% N as organic with seaweed application (N2) recorded greater growth and yield *viz.,* pod, forage and crop (maize) equivalent yield (1.51, 6 and 2.01 t ha^{-1}), respectively. Total nodules plant^{-1} were significantly influenced by crop geometry and nutrient management, whereas the total chlorophyll content of cowpea was significantly varied with nutrient management. Regression studies depicted the negative functional relationship between pod yield and canopy temperature, whereas the relationship between intercepted photosynthetic active radiation (PAR) and pod yield was positive.

Key words: CEY, Cowpea, Growth rate, INM, Intercrop, Nodule, Regression studies. Seaweed.

INTRODUCTION

The cereal legume intercropping system is one of the most suitable and valuable established cropping systems to maintain the food and nutritional security of the nation. It plays a pivotal role in challenging agriculture situations like burgeoning food demand, degradation of land productivity and scarcity of natural resources (Layek *et al*., 2018). Such as, inorganic N fertilizers (RDN) are responsible for increasing crop productivity in the short term while injudiciously and excessive application of inorganic fertilizers (RDN) deteriorates the soil health in the long term. Therefore, it is urgent to exploit the potentiality of leguminous biological nitrogen fixation (BNF) to reduce the reliance on inorganic N fertilizer (RDN) (Shukla and Mishra, 2020). However, the high nitrogen demand of cereals can be fulfilled by legume through the atmospheric nitrogen fixation technology, improve the soil fertility (Caviglia *et al*., 2011; Adigbo *et al*., 2013) and enhance temporal and spatial complementary resources (Ghanbari *et al*., 2010; Midega *et al*., 2014). Besides that, Cowpea (*Vigna unguiculata* L.) is a herbaceous legume crop with high nutritive value providing food and forage to the human population and livestock, respectively. Cowpea in the intercropping system with maize provide nutritious forage helps in energy protein synchronization for dual purpose livestock. Many researchers reported that integrated nutrient management, *i.e.*, the combination of organic and inorganic nutrient sources, reduces the environmental pollution, soil hazard and cost of crop production and help in crop productivity (Zhang *et al*., 2004; Blumenberg *et al*., 2013). Vermicompost consider as a good source of organic manure used in integrated nutrient management practices. Because vermicompost contains several macro and micronutrients, which are essential for the growth and development of many crops. However, it is responsible for releasing phytohormone and acting for buffering the soil, resulting in a plant can readily uptake

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different nutrients. Other than the vermicompost, mustard oil cake (MOC) was also popularised as organic component used in integrated nutrient management (INM) practices as it has the properties to provide nutrients and pesticides to control weeds, insect pests, nematodes and pathogens (Rahman *et al.*, 2018). Seaweed (marine algae) act as a biostimulant used in small quantity integration with different INM practices, significantly enhancing the growth and quality of crops and securing agricultural susceptibility (Thavaprakaash *et al.*, 2005). Seaweed is enriched with several mineral nutrients, essential amino acids, phytohormone and carbohydrates, recognized as 'metabolic enhancers', liable for enhancing crop productivity. Number of studies have revealed a wide range of beneficial effects of seaweed applications on plants, such as early seed germination and establishment, improved crop performance and yield, elevated resistance to biotic and abiotic stress and enhanced post harvest shelf-life of perishable products (Khan *et al.*, 2009).

So, to achieve food security with nutritional security, the management practices which are environment friendly, utilize all the natural resources efficiently, ensure environmental safety and help in building sustainable agriculture under long-run integrated nutrient management has been found to give a satisfactory result.

MATERIALS AND METHODS

The field experiment was conducted at "Jaguli Instructional Farm" of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, under New Alluvial Zone of West Bengal to evaluate the "Growth and yield responses of cowpea (*Vigna unguiculata* L.) as influenced by crop geometry and nutrient management practices" during the period of *Kharif* 2019 and 2020. The experimental site was situated in the sub-tropical sub-humid climatic zone of eastern India. Average annual rainfall was 1260 mm and 80% of it was received during the month of June to September. Meteorological observations were recorded during the crop growing period which were shown in Fig 1. The soil of the experimental field was typical Gangetic alluvium (Entisol) type with sandy loam in texture with well drainage facility, having medium soil fertility status. The soil of the experiment was neutral in reaction, low in available nitrogen, medium in available phosphorus, potassium and organic carbon. The experiment on *Kharif* maize +cowpea intercropping was laid out in split plot design comprising of twenty-five treatment combination (five crop geometry allocated in main plot and five nutrient management in sub plot) with three replication. This intercropping experiment was continued for two consecutive *Kharif* seasons on the same field. In this cereal legume intercropping system, dual purpose cowpea variety 'Kashi Kanchan' was taken as a test crop. The main plot treatments were Sole maize (C1), Sole cowpea (C2), Maize + Cowpea (1M:1C) (C3), Maize + Cowpea (2M:1C) (C4), Maize + Cowpea (1M:2C) (C5) were allocated in main plots while the subplots treatments were 100% RDN as chemical (N1), 75% N as chemical +25% N as organic +seaweed (N2), 50% N as chemical +50% N as organic +seaweed (N3), 25% N as chemical + 75% N as organic +seaweed (N4) and 100% N as organic (N5). The recommended dose of fertilizer (RDF) for maize and cowpea were 150:75:75 (N:P:K) kg ha^{-1} and 20: 40:40 (N:P:K) kg ha^{-1} respectively. Vermicompost and mustard oil cake were used as an organic source and seaweed (Sagarika) as a biostimulant was used in granule form as a basal application in soil.

Periodically biometric observations, pod and forage yield were recorded at the time of harvest maturity. PAR and canopy temperature were measured with the help of quantum sensor and infrared thermometer. CGR and RGR were calculated using the following formula:

$$\text{Crop growth rate (CGR) (g m}^{-2}\text{ day}^{-1}) = \frac{(w_2 - w_1)}{(t_2 - t_1)}$$

$$\text{Relative growth rate (RGR) (mg g}^{-1}\text{ day}^{-1}) = \frac{\log(w_2) - \log(w_1)}{(t_2 - t_1)}$$

Finally, after completion of experiment in two years, system productivity was calculated as crop equivalent yield using following formula:

$$\text{Crop equivalent yield (CEY)} = \sum_{i=1}^{n} (\text{yi.ei})$$

$$e = \frac{P_{bc}}{p_i}$$

Where,

Y_i is yield of i^{th} component.

e_i is equivalent factor.

P_i is price of the i^{th} crop.

P_{bc} is price of the crop to which yield is converted.

Data recorded on various parameters were analyzed by 'Analysis of Variance' (ANOVA) in split plot design (Gomez and Gomez, 1984). The significance of difference for sources were tested by 'F' test at significance level of 5% (P = 0.05). For mean comparison of 'F' value as well as 'Tukey HSD' test were used with the help of 'statistix 10' software.

RESULTS AND DISCUSSION

Growth and yield of cowpea

Data pertaining in Table 1 revealed that the growth, yield attributing parameters and yield of sole cowpea (C2) was significantly ($p<0.05$) varied from lowest value. From this investigation, it was found that significantly higher plant height (74.01 and 82.78 cm) was obtained from the intercropping treatment (2M:1C) at 50 DAS and harvest, respectively. This could be attributed by the interspecific competition with associated crops for getting more intercepted light. Same findings also recorded by Alla *et al.* (2014). Whereas, rest of the growth parameters like number of leaves (57.73 and 81.97), leaf area index (LAI) (3.19 and 3.66) at different growth stages (50 DAS and harvest) and number of branches (5.82) at harvest gave better result in solid culture (C2) than intercropping, respectively. Among the intercropping systems, 1M:1C treatment (C3) had

Table 1: Effect of crop geometry and nutrient management on growth, yield attributes and yield of cowpea in *kharif* maize + cowpea intercropping system (Pooled of two consecutive year).

Treatment	Plant height (cm)		No. of leaves		Leaf area index		No. of branches	No. of pods plant^{-1}	Pod length (cm)	Pod yield (t ha^{-1})	Forage yield (t ha^{-1})	CEY (t ha^{-1})
	50 DAS	Harvest	50 DAS	Harvest	50 DAS	Harvest	Harvest	Harvest	Harvest	Harvest	Harvest	Harvest
Crop geometry												
C1	-	-	-	-	-	-	-	-	-	-	-	-
C2	66.52^{c}	75.91^{c}	57.73^{a}	81.97^{a}	3.19^{a}	3.66^{a}	5.82^{a}	21.59^{a}	29.73^{a}	2.01^{a}	7.08^{a}	2.58^{a}
C3	71.79^{ab}	81.27^{ab}	52.79^{b}	77.69^{ab}	3.09^{a}	3.51^{ab}	5.54^{a}	19.40^{b}	26.59^{b}	1.30^{b}	5.49^{b}	1.76^{b}
C4	74.01a	82.78a	42.24^{d}	68.19^{c}	2.71^{b}	3.17^{c}	4.79^{b}	17.79^{c}	24.32^{b}	0.71^{c}	3.66^{c}	1.02^{d}
C5	69.65^{bc}	78.09^{bc}	48.46^{c}	75.89^{b}	2.85^{b}	3.39^{bc}	5.32^{ab}	18.30^{c}	24.78^{b}	1.25^{b}	5.22^{b}	1.69^{c}
SEm(±)	0.47	0.66	0.48	0.69	0.04	0.04	0.10	0.08	0.46	0.02	0.11	0.02
Nutrient management												
N1	73.26^{a}	81.94^{ab}	52.83^{a}	78.41^{b}	3.13^{a}	3.54^{ab}	5.46^{ab}	19.92^{b}	26.98^{ab}	1.34^{b}	5.58^{b}	1.81^{b}
N2	71.48^{ab}	83.00^{a}	51.53^{ab}	87.23^{a}	3.10^{a}	3.71^{a}	5.67^{a}	20.95^{a}	28.51^{a}	1.51^{a}	6.00^{a}	2.01^{a}
N3	70.75^{abc}	79.43^{bc}	50.04^{bc}	73.29^{c}	2.96^{b}	3.42^{b}	5.38^{b}	19.10^{c}	26.06^{ab}	1.30^{b}	5.37^{b}	1.75^{bc}
N4	68.90^{bc}	77.59^{cd}	49.13^{cd}	71.92^{cd}	2.93^{b}	3.40^{b}	5.24^{bc}	18.53^{d}	25.63^{b}	1.26^{bc}	5.21^{b}	1.70^{c}
N5	68.07^{c}	75.61^{d}	48.00^{d}	68.83^{d}	2.69^{c}	3.10^{c}	5.09^{c}	17.85^{e}	24.59^{b}	1.18^{c}	4.64^{c}	1.56^{d}
SEm(±)	0.49	0.57	0.35	0.80	0.03	0.04	0.07	0.08	0.51	0.02	0.07	0.02

C1- Sole maize; C2- Sole Cowpea; C3- Maize + Cowpea (1M:1C); C4- Maize + Cowpea (2M:1C); C5- Maize + Cowpea (1M:2C); N1 = 100% RDN (chemical); N2 = 75% N (chemical) + 25% N (organic) + Seaweed; N3 = 50% N (chemical) + 50% N (organic) + Seaweed; N4 = 25% N (chemical) + 75% N (organic) + Seaweed; N5 = 100% N (organic). *CEY- Crop (maize) equivalent yield of cowpea.

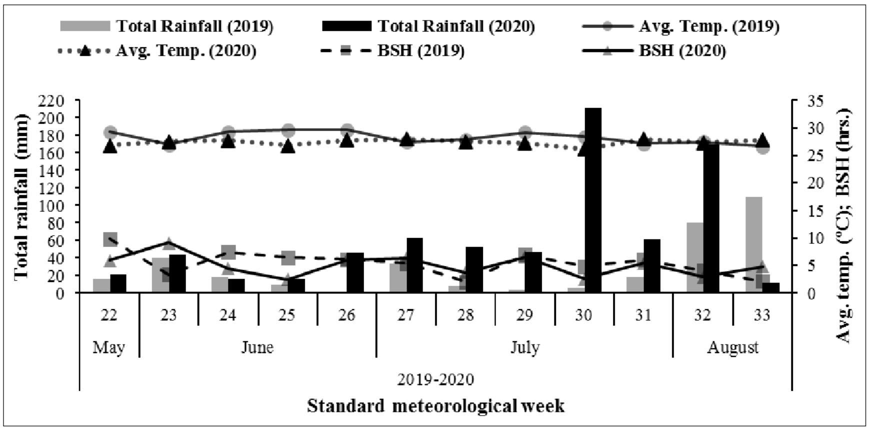

Fig 1: Meteorological observation during crop growing period.
*BSH- Bright sunshine hours.

highest growth like number of leaves (52.79 and 77.69), leaf area index (LAI) (3.09 and 3.51) at different growth stages (50 DAS and harvest) and number of branches (5.54) at harvest. This is due to the competition between cowpea plant with the tall companion crop (maize) for resource use like intercepting of photosynthetically active radiation (Abd El-Lateef *et al.*, 2015). Similar to growth parameters, yield attributing characters *viz.,* number of pods (21.59) and pod length (29.73 cm), cowpea pod yield (2.01 t ha^{-1}), forage yield (7.08 t ha^{-1}) and CEY of cowpea (2.58 t ha^{-1}) showed maximum value under sole cowpea followed by different intercropping systems. The reduction of cowpea yield by intercropping may be due to interspecific competition, suppressiveness and shading effect imposed by C4 plant maize remains in the mixture. These findings confirm the result of Ghosh (2004); Abd El-Lateef *et al.* (2015); Ghosh *et al.* (2006); Banik *et al.* (2006). Besides that, it also decreased the photosynthesize metabolites transportation from source to sink resulted decrease in yield. Among the intercropping treatments, comparatively higher yield attributing characters number of pods (19.40), pod length (26.59 cm), pod yield (1.30 t ha^{-1}), forage yield (5.49 t ha^{-1}) and CEY of cowpea (1.76 t ha^{-1}) were obtained from the treatment 1M:1C (C3) followed by 1M:2C (C5) (18.30, 24.78 cm, 1.25 t ha^{-1}, 5.22 t ha^{-1}, 1.69 t ha^{-1}), respectively. The yield variation in intercropping system was due to the different proportion of cowpea plant in the mixture *i.e.*, 50%, 33% and 67% cultivated area had been occupied by various intercropping pattern (1M:1C, 2M:1C and 1M:2C), respectively (Abd El-Lateef *et al*., 2015). Regarding nutrient management, the maximum growth was observed in fully inorganic treatment (N1) during early stage (50 DAS) of the crop whereas, higher growth was recorded in integrated nutrient management treatment (N2) at the time of harvest. As because of easily available of nutrient at early stage from inorganic sources, although in later stage increased supply of nutrient through integrated sources due to efficient utilization of nutrient and slowly availability of nutrient (Thavaprakaash *et al*., 2005). The cowpea pod yield (12.68% and 27.96%), forage yield (7.52% and 29.31%) and CEY of cowpea (11.04% and 28.85%) were significantly increased in integrated treatment (N2) compared to fully inorganic and fully organic treatment, respectively. In the same pattern all yield contributing parameters *i.e.*, number of pods plant^{-1} (5.17% and 17.36%) and pod length (5.67% and 15.94%) were enhanced by integrated treatment (N2) than fully inorganic and fully organic treatment, respectively. As integrated nutrient management treatment (75% N as chemical+25% N as organic + seaweed) (N2) improve the growth resultant better source-sink relationship and photosynthetic rate which reflects in higher cowpea yield (Pod, forage and crop equivalent yield) (Das *et al*., 2011; Kumar *et al*., 2016; Thavaprakaash *et al*., 2005). Besides that, increased cowpea yields also described by the influence of seaweed contains growth hormone, mineral, trace element which act as a biostimulator for plant growth and development (Khan *et al*., 2009).

In the pooled data of two years experiment (2019-2020), significant ($P<0.05$) interaction effects among the years, crop geometry and nutrient management on various yield attributing parameters as well as on yield are depicted in Table 2. There was non-significant interaction between the years with different treatments on LAI, pod length, total number of nodules and pod yield whereas significant on number of pods plant^{-1}. Interestingly, it was noted that interaction effect of two treatments *i.e.*, crop geometry and nutrient management was significant on LAI, pod length, total number of nodules and pod yield at harvest.

Regression studies

Response of cowpea pod yield to crop canopy temperature affected by crop geometry and nutrient management is tabulated in Table 3. In this investigation, it was analyzed that significantly negative functional relationship was occurred between crop canopy temperature with yield. It was reported that the cowpea pod yield was determined by canopy temperature at 30 DAS influenced by crop geometry and nutrient management through the equation (i and ii), respectively. Accordingly, the cowpea pod yield was determined by canopy temperature at 50 DAS influenced by crop geometry and nutrient management through the equation (iii and iv), respectively. Finally, the expected yield was calculated by observing crop canopy temperature at the time of harvest through the equation (v and vi), respectively. The coefficient of determination explained 86.7% and 73.5%; 85.8% and 65.8%; 79.8% and 67.3% variability in cowpea pod yield due to canopy temperature which was affected by crop geometry and nutrient management at 30 DAS, 50 DAS and harvest of crop, respectively. These findings confirm with the findings of Marois *et al.* (2004); Carroll *et al.* (2017); Kaur *et al.* (2018). Regression studies between PAR and cowpea pod yield was depicted in Fig 2. Here, intercepted PAR was positively correlated with pod yield of cowpea and R^2 value from 0.6596

Table 2: Interactive effect of year (Y), crop geometry (C) and nutrient management (N) on leaf area index (LAI), number of pods plant^{-1}, pod length, total nodules number and pod yield (Pooled of two consecutive year).

Interaction effect	Leaf area index		No. of pods	Pods length	No. of nodule		Pod yield
	50 DAS	Harvest	plant^{-1}	(cm)	50 DAS	Harvest	(t ha^{-1})
YxC	NS	NS	*	NS	NS	NS	NS
YxN	NS	NS	*	NS	NS	NS	NS
CxN	NS	*	*	*	NS	*	*
YxCxN	NS	NS	*	NS	NS	NS	NS

Significance denoted by symbol * at $P<0.05$ level; NS- non-significant.

Table 3: Effect of canopy temperature on yield response of cowpea crop (Pooled of two consecutive year).

Treatment	x	Advancement of growth stages	Response equation for yield (y)		R^2 value
Crop geometry		30 DAS	$y = 0.0026x^2 - 0.3211x + 9.0317$	(i)	$R^2 = 0.867$
Nutrient management			$y = -0.0246x^2 + 1.5708x - 23.65$	(ii)	$R^2 = 0.735$
Crop geometry	Canopy	50 DAS	$y = 0.0064x^2 - 0.5531x + 12.294$	(iii)	$R^2 = 0.858$
Nutrient management	temperature		$y = -0.0164x^2 + 0.9763x - 13.093$	(iv)	$R^2 = 0.658$
Crop geometry		Harvest	$y = 0.0088x^2 - 0.6452x + 12.441$	(v)	$R^2 = 0.798$
Nutrient management			$y = -0.0189x^2 + 1.0143x - 12.188$	(v)	$R^2 = 0.673$

*The measured yield fits a polynomial equation '$y=ax^2+bx+c$'; where, x variable represents canopy temperature (^{0}C) affected by treatments (crop geometry and nutrient management) in different advancement of growth stages.

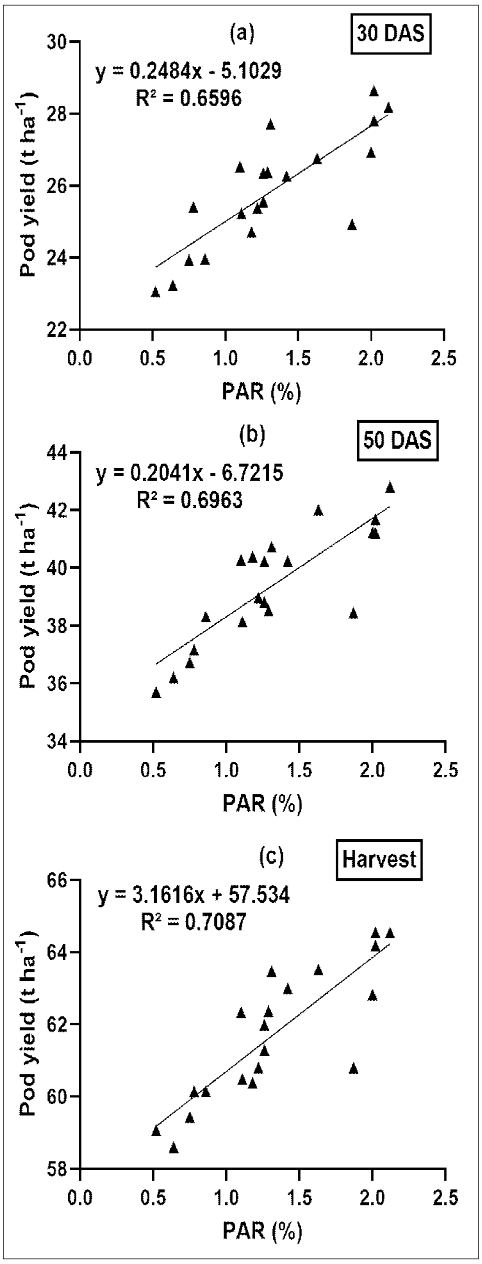

Fig 2: Regression analysis between pod yield and PAR (photosynthetic active radiation) at different advancement of growth stages (a, b, c) of cowpea crop (Pooled of two consecutive year).

to 0.7087 was increasing with advancement of crop growth stage. It was known to all that higher R^2 value predict the more accuracy in pod yield of cowpea which was obtained at crop harvest time (0.7087) followed by at 50 DAS (0.6963) and at 30 DAS (0.6596). With advancement of crop growth, the growth parameters like leaf volume and chlorophyll content were increased, simultaneously. Absorption of the more intercepted PAR *i.e.*, radiant energy converts into chemical energy through photosynthesis process which turn into the crop biological yield (Jena *et al.*, 2015a; Jena *et al.*, 2010b).

Total nodules number

From the pooled data of two years (2019-2020), it was shown that total nodules number per plant were less in intercrop cowpea (C3; C5 and C4) (24.85, 41.90; 23.07, 41.40 and 22.35, 38.93) than those in sole crop (27.39 and 43.64) at different growth stages (50 DAS and harvest), respectively (Fig 3). Higher N fertilizer was recommended for cereal crop in intercropping situation led to no N stress, conversely, legume crop require small amount of starter dose of N in initial stage for starting of root nodule formation but luxuriant soil N status hamper the nodule formation. This results closely related to the findings of Sibhatu (2016). On pooled data basis, it was reported that combination of organic, inorganic and seaweed application (N3, N2 and N4) (25.95, 25.21 and 24.71) significantly enhanced the nodule counts from the inorganic treatment (N1) (21.88) and also at par with organic treatment (N5) (24.32) at 50 DAS of crop. However, at the time of harvest, integrated nutrient management treatment (N3) (46.92) had significantly higher nodule count than rest of the treatments and lowest value showed in inorganic treatment (N1) (36.87) (Dutta *et al.*, 2021). There was significant reduction in nodule number at fully inorganic treated plot due to integrated application of organic manures in the form of vermicompost and mustard oil cake improved nodulation as nitrogen was released slowly after decomposition from these manures (Ghosh *et al.*, 2004).

Total chlorophyll content of cowpea

As shown in Fig 4 the chlorophyll content of cowpea was not significantly ($P<0.05$) affected by crop geometry at different growth stages. Although, higher chlorophyll content was recorded in sole cowpea (C2) (4.68 and 4.59 mg g^{-1} fresh wt.) over the intercropped cowpea. In the present study, intercrop cowpea recorded lower chlorophyll content than sole cowpea, which might be attributed to low availability of light due to shading effect of maize plants (Ghosh *et al.*, 2004). Cowpea growth and chlorophyll content was reduced due to the vigorous growth of maize in intercropping situation diminish the nutritional status of associated crop (Prasanthi and Venkateswaralu, 2014; Amini *et al.*, 2013). Among the nutrient management treatments, total chlorophyll content was significantly higher in integrated plot (N3) (4.24 and 4.13 mg g^{-1} fresh wt.) compare to organic (N5) (3.93 and 3.77 mg g^{-1} fresh wt.) and inorganic plot (N1) (3.71 and 3.57 mg g^{-1} fresh wt.) at different growth stages (30 DAS and 50 DAS), accordingly due to more N availability in INM treatments as N is the major constituent for chlorophyll formation (Ghosh *et al.*, 2004; Jangir *et al.*, 2021).

Growth rate of cowpea

On pooled of two years, crop growth rate (CGR) of cowpea is illustrated in figure 5. Among the crop geometry, sole cowpea had significantly higher CGR value (3.90 g m^{-2} day^{-1}) followed by intercropping treatment (1M:1C) (3.17 g m^{-2} day^{-1}) at growth period of 30-50 DAS. However, 75% N as chemical+25% N as organic +seaweed combination (N2) gave the significantly higher CGR (4.25 g m^{-2} day^{-1}) which was at par with fully inorganic treatment (N1) (3.77 g m^{-2} day^{-1}). During the growth period of 50 DAS-harvest, highest CGR (8.18, 5.64 g m^{-2} day^{-1}) was obtained in sole cowpea (C2) and 75% N as chemical+25% N as organic +seaweed combination (N2), respectively. Here, it was observed that CGR was increased from 30-50 DAS to 50 DAS-harvest for both treatments. Higher LAI and greater absorption of PAR influence the crop growth rate (CGR) of different crop geometry treatments (Karimi and Siddique, 1991; Addo-

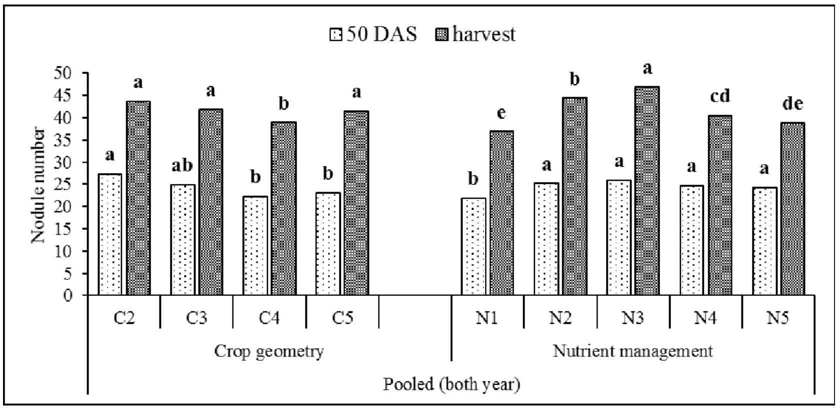

Fig 3: Effect of crop geometry and nutrient management on cowpea root nodule number at different growth stages (50 DAS and harvest) (Pooled of two consecutive year).

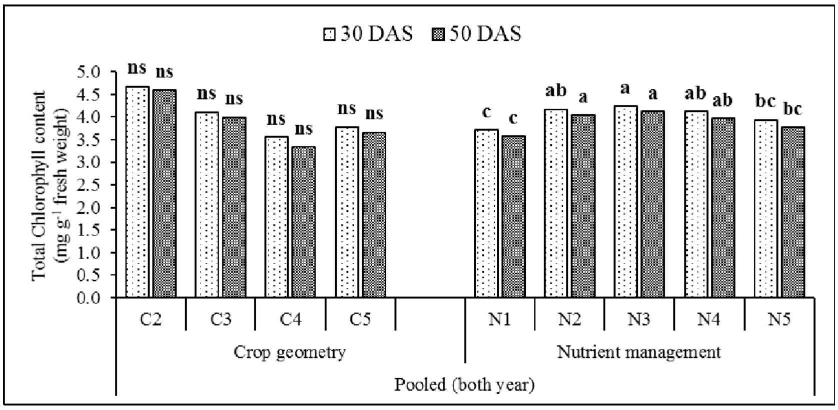

Fig 4: Effect of crop geometry and nutrient management on total Chlorophyll content of cowpea at different growth stages (30 and 50 DAS (days after sowing)) (Pooled of two consecutive year).

C1 = Sole maize; C2 = Sole Cowpea; C3 = Maize + Cowpea (1M:1C); C4 = Maize + Cowpea (2M:1C); C5 = Maize + Cowpea (1M:2C); N1 = 100% RDN (chemical); N2 = 75% N (chemical) + 25% N (organic) + Seaweed; N3 = 50% N (chemical) + 50% N (organic) + Seaweed; N4 = 25% N (chemical) + 75% N (organic) + Seaweed; N5 = 100% N (organic).

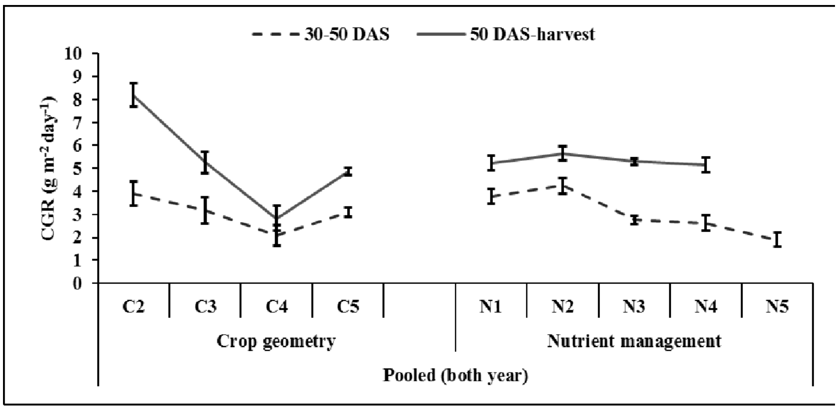

Fig 5: Effect of crop geometry and nutrient management on crop growth rate (CGR) of cowpea at different growth stages interval (Pooled of two consecutive year)

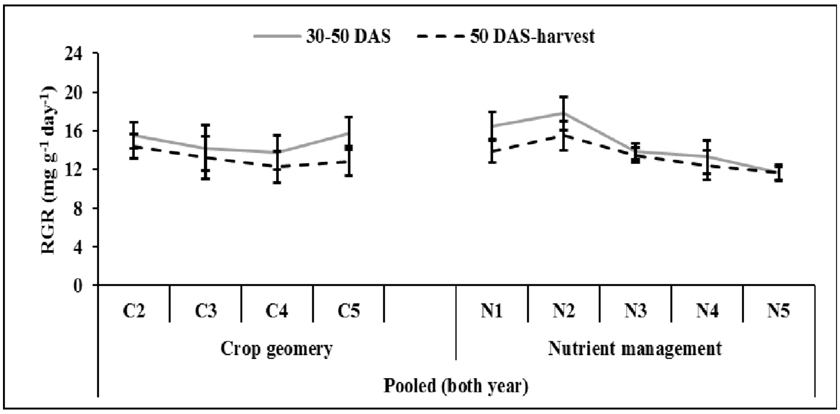

Fig 6: Effect of crop geometry and nutrient management on relative growth rate (RGR) of cowpea at different growth stages interval (Pooled of two consecutive year).

C1 = Sole maize; C2 = Sole Cowpea; C3 = Maize + Cowpea (1M:1C); C4 = Maize + Cowpea (2M:1C); C5 = Maize + Cowpea (1M:2C); N1 = 100% RDN (chemical); N2 = 75% N (chemical) + 25% N (organic) + Seaweed; N3 = 50% N (chemical) + 50% N (organic) + Seaweed; N4 = 25% N (chemical) + 75% N (organic) + Seaweed; N5 = 100% N (organic).

Quaye *et al*., 2011). Besides this, the application of seaweed with organic and inorganic combination enhances the crop growth rate by the production of growth stimulating phytohormones (Basavaraja *et al*., 2018).

In this experiment, relative growth rate (RGR) of the treatment is plotted in figure 6. RGR value was declined over the crop growth period. RGR was non significantly varied with different crop geometry at 30-50 DAS growth period but significantly varied at 50 DAS-harvest. Hence, RGR was significantly differed with nutrient management treatment at different growth period. This could be due to shading effect of maize which reduces the leaf area of cowpea. Therefore, reduction of light absorption capacity leads to decreasing rate of photosynthesis (Karimi and Siddique, 1991; Addo-Quaye *et al*., 2011).

CONCLUSION

After the two years of an experiment on intercropping, this has been concluded that among the intercropping system, maize +cowpea intercropping (1M:1C), *i.e*., C3 was found to be a superior treatment for achieving greater growth attributes, growth rates (CGR and RGR) and fruit yield of cowpea crop. Regarding the nutrient management practices, 75% RDN+25% organic (vermicompost and mustard oilcake) +seaweed, *i.e*., N2 treatment was recommended for contributing the highest cowpea productivity. Although, C3 and N3 (50% RDN+50% organic (vermicompost and mustard oilcake) +seaweed) treatments provide higher number of nodule and total leaf chlorophyll content, which greatly influence the biological nitrogen fixation (BNF) and cowpea yield.

Conflict of interest: None.

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