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Determination of effective spatial arrangement for intercropping of maize+soybean using dry matter yield and competition interaction

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Abstract
A field experiment was conducted during Kharif 2016 at CPGS, CAU, Umiam, Meghalaya. The soil was sandy clay loam in texture, moderately acidic in reaction (pH 5.23), high in soil organic carbon (1.02 %) and medium in available Nitrogen, Phosphorus and Potassium (315.04, 16.34 and 196.12 kg ha^{-1}, respectively). The experiment consist of eight treatments such as sole maize, sole soybean, 1:1replacement, 1:1additive, 2:1replacement, 2:1additive, 2:1paired and 2:2paired) replicated thrice in randomized block design. Maximum plant population recorded from sole plant arrangement in both the crops. However, at harvest soybean population recorded with 1:1replacement was significantly higher over all the remaining intercrop treatments. Significantly higher dry matter accumulation recorded from sole arrangement of both the crop except 1:1replacement is at par. Significantly higher value of crop growth rate and relative growth rate at 30-60 Days after sowing in maize and soybean observed in 1:1replacement and sole soybean respectively. However, maximum net assimilation rate recorded from both the crop in 2:1replacement intercropped treatment. Maximum values of land equivalent ratio, area time equivalent ratio and Total Relative Yield recorded from 2:2paired followed by 1:1additive and 1:1replacement intercropped treatments. Relative Efficiency Index of intercropping at 0-30 days after sowing was significantly higher in 2:1additive planting arrangement over all the intercropping treatments. There is no significantly difference in harvest index maize and soybean due to spatial arrangement except 2:1paired in maize and sole soybean in soybean has significantly lower harvest index. The finding is concluding that 1:1replacement has better growth habit has compared to other intercropped treatments.

Keywords: additive, dry matter, intercropping, replacement, relative efficiency index

Introduction
Using new scientific methods for meeting increasingly growing population demands is required. Diversification of cropping system is necessary to get higher dry matter yield and to maintain sustainability of soil, preserve environment and meet daily food and fodder requirements of human and animal respectively (Padhi and Panigrahi, 2006) [22]. Thus, not only the number of crops but types of crops included in the intercropping system is also important. The suitable intercropping systems might increase the total production through efficient utilization of production factors like space, water, nutrient etc. and stability of crop yield in rainfed conditions can be achieved with crop substitution and intercropping (Dutta and Bandyopadhyay, 2006) [9]. Instead of growing of sole maize, intercropping with soybean can be more profitable in the rainfed condition (Dhima *et al.* 2007) [8]. Apart from improvement and maintenance of soil fertility, intercropping with soybean is found to be remunerative because under legume and non-legume intercropping situation, legume can fix atmospheric nitrogen which may be available to associated non-legumes.

Changing the planting pattern of the main and component crops is important agronomic approach in intercropping systems but has not been extensively studied. Spatial arrangements of plant, plant population and maturity dates must have important effect of competition between component crops and their productivity (Ghosh, 2004) [11]. However, in intensive intercropping systems like additive series, where the base crop population is maintained at 100% and intercrops are introduced through replacement series of crop geometry, there is likelihood of some influence of base crops on the performance of intercrops. This may affect the normal growth and physiological processes of the intercrops leading to below par performance (Kamanga *et al.*, 2010) [15].

A number of indices such as land equivalent ratio, relative yield, relative yield total, harvest index, relative efficiency index, area time equivalent ratio and physiological parameters of plant such as crop growth rate, relative growth rate, net assimilation rate and dry matter accumulation etc., have been proposed to describe competition within intercropping systems (Banik *et al.* 2006, Dhima *et al.* 2007) [5, 8]. The objectives of the present study were (i) to determine the effective space required for maize+soybean intercropping systems (ii) to examine different competition interaction in the intercropping systems.

Materials and Methods

A field experiment was conducted during kharif 2016 on experimental farm of College of Post Graduate Studies, CAU, Umiam, Meghalaya. The soil was sandy clay loam, moderately acidic, medium in available N (315.04 kg/ha), P (16.34 kg/ha) and K (196.12 kg/ha) with soil pH 5.23. The experiment consisted of 8 treatment had sole crops, *viz.* maize at 60 cm × 20 cm and soybean 30 cm × 10 cm and 6 combination of maize intercropped with soybean in 1:1R (spacing of both the crops are 45 cm to maintain 67% population maize and soybean was grown alternatively with maize for accommodating 33% population of their sole population), 1:1A (single row of soybean between 2 rows of maize at normal spacing 60 cm), 2:1 R (each pair of maize planted at 60 cm in between, alternate with one row of soybean at 45 cm to maintain 83% and 17% of their sole population respectively), 2:1A (single row of soybean between 2 pair of maize at normal spacing 60 cm), 2:1P and 2:2P (one and two rows of soybean between two paired rows of maize, spaced 90 cm apart at 2:1P and 2:2P treatments). The experiment was laid out in randomized block design with 3 replications. The cultivars used in the study were DA-61-A (maize) and JS-335 (soybean). They were sown simultaneously in last weeks of June 2016. The overall rainfall received during the cropping period (June-October) was 1414 mm. Recommended dose of fertilizer of 80-60-40 NPK kg/ha for maize applied As 50% N and full dose of P and K basal dose and remaining 50% N applied as two split 30 and 50 DAS respectively, 20-60-40 NPK kg/ha for soybean applied as full basal dose and for intercropping fertilizer applied on the basis of their plant population. And other recommended packages and practices were followed during the growing period of the crops and harvested in order on 4th and 20th October, 2016. All the observations were measured as per the standard procedures. Data statistically analyzed by using the technique of analysis of variance and difference between the treatment means was tested as to their statistical significance with appropriate critical difference value at 5% level of probability (Gomez and Gomez, 1984). The competitive functions were computed in the form of land equivalent ratio (LER), relative yield (RY), relative yield total (RYT), harvest index (HI), relative efficiency index (REI) and area time equivalent ratio (ATER).

Physiological Parameters

Crop growth rate (CGR)

The rate of dry matter production per unit land area per unit time or crop growth rate (CGR) was calculated by using the formula and expressed as g m^{-2} day^{-1}.

$$\text{CGR (g m}^{-2}\text{ day}^{-1}) = \frac{(W_2 - W_1)}{P \times (t_2 - t_1)}$$

Relative growth rate (RGR)

Relative growth rate (RGR, mg g^{-1} day^{-1}) is the rate of increase in dry matter weight per unit dry weight expressed in mg g^{-1} day^{-1} was calculated by using the formula suggested by Blackman (1919).

$$\text{RGR (mg g}^{-1}\text{ day}^{-1}) = \frac{(\text{Log } W_2 - \text{Log } W_1)}{t_2 - t_1}$$

Net assimilation rate (NAR)

Net assimilation rate (NAR) is the rate of increase of dry matter per unit of leaf area expressed in g cm^{-2} day^{-1}, was calculated using the formula.

$$\text{NAR (g cm}^{-2}\text{ day}^{-1}) = \frac{(W_2 - W_1) \times (\text{Log } L_2 - \text{Log } L_1)}{(t_2 - t_1)(L_2 - L_1)}$$

Where,
W_1 and W_2 = Dry matter production (g) per plant at time t_1 and t_2 respectively,
L_2 and L_1 = Leaf area (cm^2) per plant
P = Ground area covered by the plant (cm^2)

Calculations

Land Equivalent Ratio (LER)

LER is defined as the relative land area under sole crop that is required to produce the yield achieved in intercropping. LER is calculated as the sum of the partial LER values (L) of each of the intercrop components (LER_1 and LER_2) (Willey, 1979) [24].

$$LER\ 1 = \frac{Yield\ of\ maize\ in\ intercrop}{yield\ of\ maize\ in\ sole\ crop};$$

$$LER\ 2 = \frac{Yield\ of\ soybean\ in\ intercrop}{yield\ of\ soybean\ in\ sole\ crop}$$

$LER_{IC} = LER_1 + LER_2$

For DM-based LER values, yield refers to the total aboveground dry matter (DM) production and, measured at the final harvest. LER values exceeding a value of 1 imply that the intercrop is more efficient than the average sole crop, whereas values of less than 1 indicate that intercrop efficiency is lower than the average sole crop.

Relative Yield (RY)

The RY of an intercrop was determined as yield of that crop in mixture expressed as proportion of its yield in monoculture where the yield of monoculture was assumed as 100 per cent. The RYT of the mixture was computed as the sum of RY of the mixture components.

$$RY\ maize = \frac{Yield\ of\ maize\ in\ mixture}{yield\ of\ maize\ in\ sole}$$

$$RY\ soybean = \frac{Yield\ of\ soybean\ in\ mixture}{yield\ of\ soybean\ in\ sole}$$

$$RYT = \frac{Yield\ of\ maize\ in\ mixture}{yield\ of\ maize\ in\ sole} + \frac{Yield\ of\ soybean\ in\ mixture}{yield\ of\ soybean\ in\ sole}$$

Area time equivalent ratio (ATER)

ATER provides more realistic comparison of the yield advantage of intercropping over monocropping in terms of time taken by component crops in the intercropping systems than LER. ATER was calculated by formula developed by Hiebsch, 1980 [14]. The interpretation of ATER involves that ATER>1 implies yield advantage; ATER=1 no effect of intercropping; ATER<1 shows yield disadvantages.

$$ATER = \frac{(RYa\ X\ Ta) + (RYb\ X\ Tb)}{T}$$

Where;
RYa=Relative yield of component A (maize) in mixture
Ta=duration (in days) of component A (maize)
RYb=Relative yield of component species B (soybean) in mixture
Tb=duration (in days) of component B (soybean)
T=Total duration of the intercropping system (in days)

Relative Efficiency Index (REI)

As a measure of the relative performance of the components of the intercrops, the Relative Efficiency Index (REI; Connolly 1987) was calculated at each 30 days interval of total aboveground DM production [REI (DM)]. REI is an index that compares the proportional change (K) in total dry matter within a given time interval (t1 to t2), of one species relative to another.

$$REI = \frac{Kmaize}{Ksoybean}$$

$$REImaize = \frac{DM\ maize\ t1}{DM\ maize\ t2}$$

$$REIsoybean = \frac{DM\ soybean\ t2}{DM\ soybean\ t1}$$

A value of REI, is 1 means that both species display similar proportional growth or nutrient accumulation over a period of time. K_{maize} refers the dry weight of maize at time t_1 and t_2 and $K_{soybean}$ is dry weight of soybean at time t_1 and t_2

Results and Discussion

Plant population and mortality

Plant population of maize and soybean was significantly affected due to population proportion of component crops in both the cases at 30 DAS and at harvesting. Maximum plant population of maize and soybean at both the stages was recorded in sole crops which were at par with all the intercropping treatments except in case of maize having significantly higher plant population over the 2:1R and 1:1R intercropping treatments. Treatments 2:1R and 1:1R had significantly lesser plant population as compare to other intercropping treatments too at both the stages of observations. While in soybean intercropped with maize in 1:1A also recorded significantly higher plant population over all the intercropped. However, at harvest soybean population recorded with 1:1R was significantly higher over all the remaining intercrop treatments.

However, mortality percentage (%) in maize did not vary significantly due to population proportion of component crops in intercropping treatments. Maize intercropped with soybean at 2:1A recorded slightly higher mortality percentage than all the sole and other maize intercropped treatments. Maximum mortality in soybean was recorded from 2:2P treatment which was significantly superior over the sole and other intercropped treatments.

Dry matter accumulation

Sole maize recorded maximum amount of shoot and root dry matter at all the stages of observation however, it varied significantly only at 60 DAS and at harvest. At 60 DAS, shoot as well as root dry weight in sole maize was at par with 1:1R and 2:1P but significantly superior over the treatments. But harvest shoot dry weight of sole maize was at par with 1:1R, 2:1P and 2:1R but significantly superior over the other remaining intercropped treatments. The magnitude of reduction in accumulation of shoot dry matter in intercropped maize at harvest was in order of 10.3, 10.5, 12.2, 22.9, 28.8 and 39.6 % for the treatments 1:1R, 2:1P, 2:1R, 2:2P, 2:1A and 1:1A respectively, in comparison to sole maize. The magnitude of reduction in accumulation of root dry matter in intercropped maize at harvest was in order of 7.9, 16.3, 21.6, 22.8, 37.7 and 46.2 % for the treatments 2:1P, 1:1R, 2:1R, 2:2P, 1:1A and 2:1A respectively, in comparison to sole maize.

Sole soybean produced higher amount of plant shoot and root dry matter over all other treatments at all the stages. At 30 DAS and 60 DAS, shoot and root dry matter accumulation in sole soybean was significantly higher over all the treatments except shoot dry weight at 30 DAS at par with 1:1R. However, at harvest, maximum plant dry weight recorded from sole soybean was at par with 1:1R, 2:1R and 2:1P but significantly superior over the other treatments. Plant dry weight recorded at 1:1R was also significantly more over plant dry weight at all other intercrop treatments. The magnitude of decline in dry matter accumulation plant^{-1} at harvest was in order of 6.6, 10.2, 13.2, 20.9, 32.1 and 35.9 % for the treatments of 1:1R, 2:1R, 2:1P, 2:2P, 1:1A and 2:1A respectively, in comparison to sole soybean.

It is possibly better light availability and minimum competitions among the plants of component crops in soybean intercropping in paired row maize and availability of sufficient resources due to enough wider row space between the component crops in replacement series were the possible reason for this relatively better dry matter accumulation in shoots of intercropped maize plants. Eskandari *et al*. (2009) [10]; Alom *et al*. (2010) [3]; Legwaila *et al*. (2012) [18] and Mandal *et al*. (2014) [14] also reported that maximum dry matter accumulation in sole planting than intercropping treatments.

Growth Parameters

At 0-30 DAS, maximum value of CGR (g m^{-2} day^{-1}) is recorded from 2:2P which was at par with 2:1P, sole maize, 1:1R and 2:1A but significantly superior over the other treatments. At 30-60 DAS, the maximum CGR was recorded from 1:1R which was at par with 2:1P but significantly higher than the other treatments. However, at 60-harvest maximum CGR value recorded from 2:1P which was at par with all the treatment except significantly superior over the 2:1A and 1:1A. The higher value of CGR in these intercropped maize treatments over sole maize might be because of better light distribution upto lower maize leaves, sufficient availability of soil moisture and other resources due to better space availability and better planting arrangement which was also accompanied by faster growth attained by maize due to sharing of biological fixed N by intercropped soybean with associated maize and were in conformity with earlier findings of Alom *et al.* (2010) [3] and Addo-Quaye *et al.* (2011) [2]. The RGR of maize (mg m^{-2} day^{-1}) was at par at 0-30 DAS and 60-harvest stages of observation. However, at 30-60 DAS maximum RGR was recorded from 1:1R which was at par

with 2:1P, sole maize and 2:1R but statistically superior over the other intercropped maize treatments. Hayder *et al.* (2003) [13] and Mandal *et al.* (2014) [14] also reported a decline in RGR of maize in an intercropping system after 60 DAS stages of plant development. The NAR of maize (g m^{-2} day^{-1}) also behaved similar to RGR and was at par at 0-30 DAS and 60 DAS-harvest. However, at 30-60 DAS maximum NAR was recorded from 2:2P which was at par with 1:1R, 2:1R and 2:1P but significantly superior over the NAR recorded from sole maize and remaining intercrop maize treatments.
Maximum CGR of soybean at 0-30 DAS and at harvest was recorded from 2:2P which was at par with sole soybean but significantly superior over the other intercropping treatments. However, at 30-60 DAS, maximum CGR in soybean was obtained from sole soybean which was significantly higher than CGR at all the intercropping treatments. At 0-30 DAS and 30-60 DAS, maximum RGR in soybean was recorded from sole soybean however, it differed significantly over RGR recorded from all others intercropping treatments at 0-30 DAS stage of the growth only. At harvest, soybean planted with 2:2P recorded relatively higher RGR though all the treatments were at par for this trait. In present investigation, increasing trend in RGR was up to 30-60 DAS then decline due to lesser rate of dry matter production per unit of dry weight present in plants probably because of lesser light availability for carrying out photosynthesis at optimum rate. Higher NAR in soybean observed only up to 0-30 DAS and then decline thereafter probably due to shading by maize canopy not allowing sufficient sunlight to reach upto intercropped soybean and also the lower leaves of soybean acted as a parasite, causing more loss of photosynthates in photorespiration. A similar observation was reported by Addo-Quaye *et al.* (2011) [2] and Mandal *et al.* (2014) [14].

Competition interaction

Land equivalent ratio (LER)

LER is the total of partial LER of all the component crops in an intercropping system. LER value above one (1.0) indicated an advantage in land use efficiency in an intercropping system and in present investigation all intercrop treatments recorded LER above 1.00 except 2:1P intercropping treatment. The LER varied significantly due to population proportion of component crops. Maximum LER was recorded from 2:2P planting of maize+soybean while in treatment 2:1P, LER was observed only 1.0, means there was no loss or gain in yield due to intercropping of maize with soybean. This LER value was a result of significant reduction in maize grain yield due to closer planting in paired rows at 45 cm. The reason for greater LER in other intercropping treatments was due to maximum complementary use of available resources in intercropping treatments by the component crops. These results were in agreement with that of Mandal *et al.* (2014) [14], Oskoii *et al.* (2015) [21] and Paudel (2015) [23].

Area time equivalent ratio (ATER)

LER doesn't consider the duration of the crops in the field and it is based on the harvested products, and not on desired yield proportion of the component crops. Moreover, the choice of sole cropped yield for standardizing mixture yield in the estimation of LER is not clear (Willey, 1979) [24]. Therefore, area time equivalent ratio (ATER) provides more realistic comparison of the yield advantage of intercropping over sole cropping in terms of variation in time taken by the component crops of different intercropping systems (Aasim, 2008) [1]. The data presented in Table showed that ATER was significantly influenced by intercropping treatments. In all maize+soybean intercropping treatments, the ATER values were lesser than LER values (Table) indicating the over estimation of resource utilization perhaps due to the wide variations in the maturity periods of the crops of which maize stayed longer on the land and had enough time to compensate for the competition. ATER is free from problems of over estimation of resource utilization contrary to LER. In all the intercropping treatments there is no significant difference within the intercropping treatment. ATER follows similar trend of LER, the magnitude of decline ATER values of 2:2P, 1:1A, 2:1A, 1:1R, 2:1R and 2:1P. The result is conformity by (Bantie, 2015) [6].

Relative yield (RY) and Relative Yield Total (RYT)

Maximum relative yield of maize was recorded from treatment 2:1A which was at par with 2:1R while significantly higher over all the intercropped treatments. However, the higher relative yield of soybean was recorded from 1:1R which was at par with 2:2P while significantly higher over all the intercropped treatments. But the maximum total relative yield was recorded from 2:2P which was significantly higher over the 2:1P intercropped treatment other all treatments are at par levels. The RYT increased with the increase in LER. Relative yield and relative yield total are the direct determinants of intercropping superiority which are closely related with LERs (Zada and Nazar, 1988) [16].

Relative efficiency index (REI)

The REI of intercropping was highest during initial crop growth period of 0-30 DAS and lowest in 60 DAS to harvest stage even though it further increased during 60 DAS to harvest stage but much lower magnitude in all the treatments than the REI at initial crop growth (table). In present investigation REI did not vary significantly due to population proportion of component crops except 0-30 DAS. The REI of intercropping at 0-30 DAS was significantly higher in 2:1A planting population over all the intercropping treatments which was the result of many times higher dry matter production in maize plants than the intercropped soybean during similar time span. Relatively very small values of REI at 30-60 DAS in all the intercropped treatments was because of higher rate of dry matter production in soybean than the maize crop as evidenced by higher RGR in soybean during this period. Since many soybean leaves shaded during 60 DAS to harvest stage of crop growth, the rate of physiological growth measured as CGR, RGR and NAR and production of dry matter in shoots was much slower in soybean in comparison to associated maize (table and). Similar results also obtained by Hauggaard-Nielsen *et al.* (2006) [12] and Andersen *et al.* (2007) [4].

Harvest Index

Harvest index (%) of maize did not vary significantly due to population proportion of component crops in intercropping system. However, all the treatments recorded relatively higher harvest index over 2:1P intercropping. Kherorar and patra (2014) [17] and Yogesh *et al.* (2014) [25] also reported that there is no significantly difference in harvest index of due to population proportion of component crops in intercropping system. But, harvest index (%) of soybean varied significantly due to population proportion of component crops in intercropping treatments. Harvest index recorded from all intercropped soybean plots were at par among themselves but significantly higher over sole soybean. Harvest index in sole soybean was significantly lower than intercropped soybean indicated lower translocation of photosynthates towards grains because of heavy leaf shading, senescence and early aging of leaves. Matusso *et al.* (2013) [20] and Paudel *et al.* (2015) [23] also observed lower harvest index in sole soybean in comparison to intercropped soybean.

Conclusion

Thus rising of one row of maize alternate with one row of soybean in replacement planting of maize, spaced 45 cm apart and two row of maize paired with two row of soybean in between them under rainfed condition during kharif proved more suitable than the other intercropping treatments. On the basis of present investigation it was observed that treatment 1:1R was a better growth parameters and treatment 2:2P has more LER, ATER and RYT for maize-soybean intercropping system.

Table 1: Effect of spatial arrangement of maize and soybean on plant population, shoot and root dry weight of maize+soybean intercropping

Treatment	Plant population of maize			Plant Population of Soybean			Dry matter of maize shoot			Dry matter of soybean shoot			Root Dry weight of maize			Root dry weigt of soybean		
	30 DAS	Harvest	Mortality %	30 DAS	Harvest	Mortality %	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
SM	75.00	70.00	6.71	-	-	-	6.96	53.55	149.08	-	-	-	4.14	8.66	10.28	-	-	-
SS	-	-	-	233.67	164.0	29.79	-	-	-	1.94	26.25	36.30	-	-	-	1.26	3.78	6.23
1:1R	48.00	45.00	6.26	89.67	74.33	17.15	5.64	51.85	133.82	1.58	20.64	33.89	3.70	7.95	8.79	1.04	3.13	5.92
1:1A	74.00	67.33	9.01	118.00	88.00	25.44	5.08	32.10	89.99	1.34	15.71	24.63	3.24	4.43	6.43	0.65	2.27	4.72
2:1R	63.33	59.33	6.32	42.33	33.00	22.11	5.85	43.72	130.85	1.48	18.09	32.57	3.87	6.49	8.09	1.03	3.30	5.75
2:1A	72.33	65.67	9.18	42.33	27.00	36.52	6.33	33.24	106.20	1.19	14.06	23.26	3.17	5.25	5.55	0.71	1.93	4.38
2:1P	74.67	69.33	7.10	46.00	36.33	21.01	6.22	48.26	133.45	1.57	19.69	31.50	3.89	6.62	8.50	1.02	3.32	5.43
2:2P	74.33	69.00	7.13	97.33	60.67	37.65	6.37	43.05	114.94	1.41	14.46	28.69	3.03	6.94	7.97	0.91	2.91	5.36
S.E.(m)±	1.45	1.24	0.82	3.38	2.56	1.74	0.42	2.32	8.56	0.12	1.22	1.63	0.25	0.49	0.48	0.05	0.28	0.38
C.D (P=0.05)	4.45	3.83	2.54	10.41	7.90	5.36	1.30	7.13	26.38	0.36	3.77	5.03	NS	1.51	1.48	0.15	0.87	1.17

SM, Sole maize; SS, Sole soybean; R, Replacement; A, Additive; P, Paired; DAS, Days After Sowing

Table 2: Effect of spatial arrangement of maize and soybean on competition interaction in maize+soybean intercropping

								REI of intercropping		
Treatment	RY of Maize	RY of Soybean	Total RY	ATER	HI of Maize	HI of Soybean	LER	0-30 DAS	30-60 DAS	60-harvest DAS
SM	-	-	-	-	38.15	-	1.00	-	-	-
SS	-	-	-	-	-	24.73	1.00	-	-	-
1:1R	0.60	0.58	1.18	1.10	42.44	33.40	1.18	3.56	0.79	1.47
1:1A	0.77	0.44	1.22	1.16	43.02	30.91	1.22	3.18	0.69	1.88
2:1R	0.87	0.26	1.12	1.09	42.65	34.05	1.13	4.59	0.57	1.55
2:1A	0.99	0.13	1.12	1.10	47.93	30.48	1.08	6.19	0.38	1.95
2:1P	0.75	0.26	1.01	0.98	32.02	32.78	1.00	4.04	0.59	1.84
2:2P	0.73	0.50	1.23	1.16	35.56	33.60	1.24	4.77	0.66	1.35
S.E.(m)±	0.07	0.03	0.05	0.06	2.66	1.85	0.06	0.34	0.1	0.25
C.D (P=0.05)	0.20	0.08	0.17	0.19	8.20	5.69	0.17	1.06	NS	NS

SM, Sole maize; SS, Sole soybean; R, Replacement; A, Additive; P, Paired; DAS; RY, Relative Yield; ATER, Area Time Equivalent Ratio; HI, Harvest Index; LER, Land Equivalent Ratio; REI, Relative Efficiency Index; NS, Not Significant

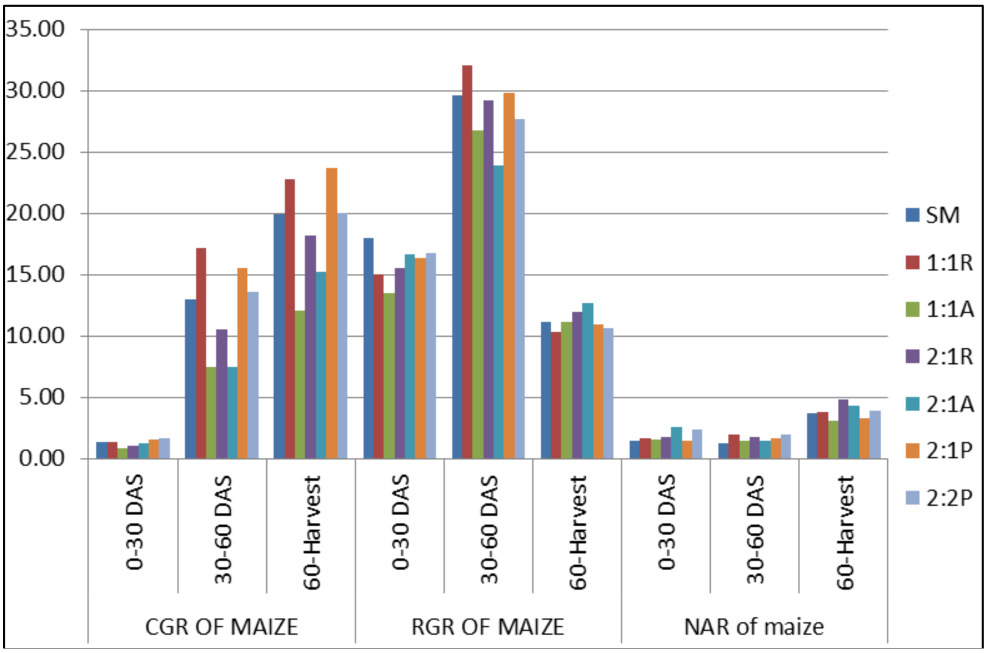

Fig 1: Effect of spatial arrangement of maize on physiological parameters in maize+soybean intercropping

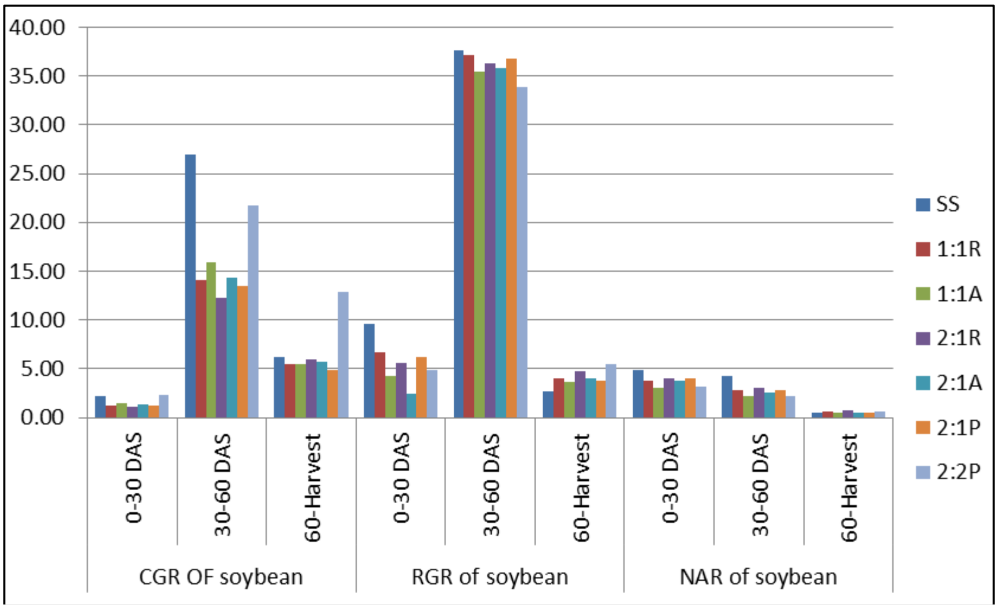

Fig 2: Effect of spatial arrangement of maize on physiological parameters in maize+soybean intercropping

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