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Effects of Intercropping on Chlorophyll Content in Maize (*Zea mays* L.) and Soybean (*Glycine max* L.)

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A B S T R A C T

This field experiment was conducted during the *kharif* season of 2014 and 2015 at the Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G) to find out the appropriate crop arrangement and fertility levels for maize and soybean intercropping system. Treatments comprised of six cropping arrangements viz. sole maize (C_1), sole soybean (C_2), two replacement series (2 maize + 2 soybean, C_3 and 2 maize + 4 soybean, C_4), two additive series (two rows (C_5) and one row (C_6) of soybean planted in-between two rows of maize and four fertility levels viz. 125% recommended dose of fertilizer (RDF) (F_1), 100% RDF (F_2), 75% RDF (F_3) and 50% RDF (F_4). Recorded SPAD value of maize and soybean leaves followed an increasing trend from 20 DAS to 60 DAS then after values decreased. Highest chlorophyll content were recorded at 60 DAS. In scenario of crop arrangement significantly higher total chlorophyll content was observed under 2:4, maize + soybean row arrangement in maize crop throughout the crop period while in soybean, sole soybean performed the highest value of this trait. Result showed higher SPAD value was observed with increasing fertility level and the treatments with 125% RDF showed significantly higher value of chlorophyll content among rest of the nutrient level.

Introduction

Intercropping of cereals with legumes has been popular in tropics and rainfed areas of the world (Dhima *et al.*, 2007) due to its advantages for soil conservation, weed control, lodging resistance, yield increment, hay curing, forage preservation over pure legumes, high crude protein percentage and protein yield and legume root parasite infections control. Intercropping of legumes in cereal was found productive economically and energetically viable (Pandey *et al.*, 2003) compared to either of the sole crops.

In the world after wheat and rice, maize is the third widely grown crop under irrigated and unirrigated condition (*Hokmalipour* and Darbandi, 2011). Maize being an exhaustive crop requires high quantity of fertilizers, particularly nitrogenous. Legumes by fixing the atmospheric nitrogen can replace the nitrogen fertilizer and increases the yield. The higher N facilitation may enable cereal to absorb more N in intercropping systems than in sole cropping systems, or it may increase the N fixation ability of legumes and may transfer from legume to cereal (Ning *et al.*, 2012). Soybean is considered as an ideal crop for intercropping with maize owing to its comparative tolerance for shade and drought, efficient light utilization and less competitiveness for soil moisture (Wright *et al.*, 1988). Nitrogen fertilizer is a key nutrient in the production of non-legume crops. It is well proven fact that nitrogen application increases chlorophyll content in crop leaves, electron transport capacity of PS I and PS II and extend the high value duration of photosynthesis rate in leaves (Yang *et al.*, 2002 and Duan *et al.*, 2007).

It also improved the photosynthetic performance and the maximum photochemical efficiency of PS II and the leaf physiological activity, delayed the senescence of the bottom and middle leaves, and increased the photosynthetic production at the late growth stage. High nitrogen fertilization level enhances the chlorophyll and carotenoid content of the leaves (Zhang *et al.*, 1997). We know that nitrogen is an undivided part of chlorophyll synthesis, thus the nitrogen status in crop can be find out with the help of chlorophyll concentration.

Materials and Methods

Field experiment was conducted during the *kharif* season in 2014 and 2015 at the Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur situated in central parts of Chhattisgarh. The hybrid maize variety Hishell and soybean variety Jawahar Soybean 97-52 (JS 97-52) were used in the experiment.

The experimental area consisted of clayey soil with pH 7.5 (neutral) with available 175.61 kg ha^{-1} Nitrogen (low), 10.752 kg ha^{-1} Phosphorus (medium) and 330.736 $kgha^{-1}$ Potash (high) at the depth of 0-30 cm. The experiment was laid out in Factorial Randomised Block Design with three replications. Maize plants were sown at a spacing of 60×20 cm^2 and soybean was spaced at an intra-row spacing of 5 cm with 30 cm inter-row spacing. Treatments comprised of six cropping arrangements viz. sole maize (C_1), sole soybean (C_2), maize + soybean in 2:2 (C_3) and 2:4 (C_4) rows in replacement series and two additive series (two rows of soybean (C_5) and one row of soybean (C_6) planted in-between two rows of maize and four fertility levels viz. 125% recommended dose of fertilizer (RDF) (F_1), 100% RDF (F_2), 75% RDF (F_3) and 50% RDF (F_4). Recommended dose of fertilizer used for maize was 110 kg N ha^{-1}, 60 P_2O_5 kg ha^{-1} and 40 K_2O kg ha^{-1} and for soybean was 20 N kg ha^{-1}, 60 P_2O_5 kg ha^{-1} and 40 K_2O kg ha^{-1}. Non-destructive Chlorophyll measurement (SPAD value) was performed four stages (20, 40, 60 and 80 DAS) by chlorophyll meter from five plants of each plot. Chlorophyll value was recorded from tagged plants with the help the SPAD meter (Kariya *et al*., 1982). The averages of top, middle and base value were expressed as SPAD (Soil plant Analysis Development) value. Average of 45 chlorophyll meter readings of leaves were taken in each plot using a portable chlorophyll meter.

Results and Discussion

Chlorophyll content (SPAD value) in Maize leaves

An increasing trend in total chlorophyll content is clearly exhibited in table 1 from 20 DAS to 60 DAS and then after it was decreased.

Maximum chlorophyll content in maize leaf was observed under 2:4, maize + soybean row arrangement throughout the crop period and the highest value was 44.97 SPAD value at 60 DAS. Mandal *et al.,* (2014) also reported the similar result. This was followed by 2:2, maize + soybean intercropping. This might be due to intercropped soybean providing atmospheric fixed nitrogen to maize in replacement and additive series. Minimum value of this trait was reported from sole maize.

Data of the table also showed that nutrient levels significantly influenced the chlorophyll content of maize. As the levels of RDF was increased, the total SPAD value was also increased (Duan *et al.,* 2007). Application of 125% RDF exhibited significantly higher chlorophyll content in leaves which was followed by 100% RDF treatment. Least chlorophyll content was observed from 50% RDF. 50% RDF (49.94 q ha^{-1}) produced minimum value of this trait. Hokmalipour and Darbandi, 2011 reported the similar result.

Chlorophyll content (SPAD value) in soybean leaves

Data depicted in Table 2 showed increasing trend in SPAD value in soybean leaves from 20 to 60 DAS. As crop moved towards maturity SPAD value decreased at and after 80 DAS. Out of six crop arrangements, sole soybean (C_2) exhibited the highest chlorophyll content in leaf in all the observational stages and this was remained comparable with 2:2 maize + soybean and (C_3) and 2:4 maize + soybean intercropping (C_4) at 60 DAS during both the years. Higher population of soybean plants showed better growth of soybean leaves in comparison to lower population. Vegetative growth of soybean was better in replacement series than additive series due to less shading effect of tall maize (Sinclair and Mouchow, 1999). Among nutrient management practice F_1 (125% RDF) observed the highest chlorophyll content and the lowest value was observed from F_4 (50% RDF). Varvel *et al.*, 1997 demonstrated N fertilizer significantly increased SPAD reading. Lowest chlorophyll content in leaves was observed from additive series C_5 with two rows of soybean added between two rows of maize.

Grain yield of maize (q ha^{-1})

Among crop arrangements mean data of 2014 and 2015 shows that C_5 produced the highest grain yield of maize and this was comparable with C_1 and C_6 and they were significantly superior over rest of the treatments. While the lowest grain yield of maize was reported from 2:4 maize + soybean intercropping (40.89 q ha^{-1}) system (C_4), during both the years as well as in mean data basis. Among nutrient management 125% RDF (62.79 q ha^{-1}) produced significantly higher maize grain yield over remaining treatments clearly showing the nitrogen content in leaves may have increased the cell division, elongation and dry matter of plant led to higher yield achievement. The treatment fertilized with 50% RDF exhibited significantly lower grain yield (49.94 q ha^{-1}) of maize during both the year as well as in mean data of two year. The highest maize yield production depended on many factors i.e. cultivars and nitrogen fertilization (Ding *et al.,* 2005). Panhwar *et al.*, (2004) also concluded that fertilizer levels exhibited highly significant effect on grain yield of maize.

Seed yield of soybean (q ha^{-1})

Data related to seed yield of soybean are presented in table 3. Out of six crop arrangements, sole soybean (C_2) produced significantly higher seed yield over rest of the crop arrangements and it was followed by C4,C3,C5 and C6 in descending order.

Table.1 Chlorophyll content (SPAD value) of maize as influenced by crop arrangement and nutrient management under maize + soybean intercropping system

Treatments	Chlorophyll content (SPAD value)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
Crop arrangement												
C_1	27.95	34.61	33.76	33.97	37.88	35.93	39.27	40.30	39.27	28.53	34.44	31.49
C_3	32.49	36.95	33.87	36.78	40.75	38.77	42.68	42.53	42.18	33.88	37.71	34.79
C_4	32.91	38.12	35.11	39.73	43.53	41.63	44.97	43.76	44.97	36.47	39.86	38.16
C_5	32.10	35.75	31.85	35.79	39.72	37.75	41.42	41.18	41.50	31.73	36.33	34.03
C_6	30.79	35.51	34.00	35.47	39.41	37.44	41.75	41.47	42.04	31.13	36.13	34.63
SEm±	0.61	0.16	0.33	0.91	0.90	0.89	0.48	0.88	0.45	1.06	1.06	0.84
CD (P=0.05)	1.70	0.44	0.93	2.55	2.51	2.49	1.35	NS	1.26	2.98	2.97	2.34
Nutrient management												
F_1	33.46	39.47	35.50	41.47	45.37	43.42	44.75	44.67	44.07	34.44	40.79	37.62
F_2	32.36	37.39	35.31	38.39	42.26	40.33	43.55	43.11	42.87	34.33	38.96	35.95
F_3	29.84	35.60	32.88	33.95	37.96	35.96	41.57	41.50	41.10	31.35	35.91	33.63
F_4	29.35	32.29	31.19	31.58	35.43	33.51	38.19	38.11	39.91	29.27	31.91	31.28
SEm±	0.54	0.14	0.30	0.81	0.80	0.80	0.43	0.79	0.40	0.95	0.95	0.75
CD (P=0.05)	1.52	0.40	0.83	2.28	2.24	2.23	1.21	2.20	1.12	2.67	2.65	2.09
C x F	NS	S	S	NS	NS	NS	S	NS	S	S	NS	NS

NS -Non-significant S – Significant; C_1-Sole maize, C_3-Maize+ soybean, 2:2, C_4-Maize+ soybean, 2:4, C_5-Two row of soybean planted in between two row of maize, C_6 -One row of soybean planted in between two row of maize, F_1-125% RDF, F_2-100% RDF, F_3-75% RDF, F_4-50% RDF

Table.2 Chlorophyll content (SPAD value) of soybean as influenced by crop arrangement and nutrient management under maize + soybean intercropping

Treatments	Chlorophyll content (SPAD value)											
	20 DAS			40 DAS			60 DAS			80 DAS		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
Crop arrangement												
C_2	27.65	29.94	28.80	31.00	34.17	32.58	40.32	40.55	40.43	39.55	39.74	39.36
C_3	26.39	28.64	27.52	29.86	33.16	31.51	39.59	38.21	38.90	38.21	37.45	37.05
C_4	26.98	28.99	27.99	30.21	33.58	31.90	39.59	38.83	39.21	38.83	38.05	37.66
C_5	25.30	27.40	26.35	28.13	28.09	28.11	37.04	35.93	36.48	36.73	35.21	35.20
C_6	25.93	28.14	27.03	29.08	32.12	30.60	37.96	37.07	37.52	37.07	36.33	35.93
SEm±	1.04	1.02	1.01	0.46	0.14	0.24	0.43	0.95	0.57	0.90	0.93	0.90
CD (P=0.05)	NS	NS	NS	1.28	0.39	0.68	1.22	2.67	1.59	NS	2.61	2.53
Nutrient management												
F_1	29.11	31.22	30.17	31.95	35.79	33.87	42.23	41.38	41.81	41.34	40.56	40.27
F_2	27.23	29.44	28.33	30.59	34.47	32.53	39.35	38.82	39.09	38.78	38.05	37.73
F_3	25.12	27.13	26.12	28.48	31.29	29.89	37.50	36.59	37.04	36.55	35.86	35.49
F_4	24.35	26.70	25.52	27.60	27.35	27.48	36.52	35.67	36.10	35.63	34.96	34.66
SEm±	0.93	0.91	0.91	0.41	0.12	0.22	0.39	0.85	0.51	0.81	0.84	0.81
CD (P=0.05)	2.61	2.56	2.53	1.14	0.35	0.61	1.09	2.39	1.42	2.26	2.34	2.26
C x F	NS	NS	NS	NS	S	S	NS	NS	NS	NS	NS	NS

NS -Non-significant S – Significant C_2-Sole soybean, C_3-Maize+ soybean, 2:2, C_4-Maize+ soybean, 2:4, C_5-Two row of soybean planted in between two row of maize, C_6 -One row of soybean planted in between two row of maize, F_1-125% RDF, F_2-100% RDF, F_3-75% RDF, F_4-50% RDF

Table.3 Chlorophyll content (SPAD value) of soybean as influenced by crop arrangement and nutrient management under maize + soybean intercropping

Treatment	Grain yield of Maize (q ha^{-1})	Grain yield of Soybean (q ha^{-1})
Cropping arrangement		
C_1	61.46	-
C_2	-	14.41
C_3	58.21	1.70
C_4	40.89	2.88
C_5	61.65	1.07
C_6	61.12	0.93
SEm±	0.93	0.12
CD (P=0.05)	2.61	0.34
Nutrient management		
F_1	62.79	4.96
F_2	59.64	4.41
F_3	54.30	3.39
F_4	49.94	3.49
SEm±	0.84	0.11
CD (P=0.05)	2.34	0.30

C_1- Sole maize, C_2-Sole soybean, C_3-Maize+ soybean, 2:2, C_4-Maize+ soybean, 2:4, C_5-Two row of soybean planted in between two row of maize, C_6 -One row of soybean planted in between two row of maize, F_1-125% RDF, F_2-100% RDF, F_3-75% RDF, F_4-50% RDF

Under maize + soybean intercropping systems, soybean yield tends to be lower and maize yield tends to be higher (Ghaffarzaeh *et al*., 1994). Greater number of branches and leaves could have influenced the monocropped soybean to produce greater number of pods plant^{-1} as well as higher seeds pod^{-1} (Data is not presented here) leading to higher seed yield (Ijoyah *et al*., 2010; Kebebew *et al*., 2014). However, the two additive series produced comparable seed yield of soybean.

Among nutrient management 125% RDF produced the highest seed yield and the lowest producer was F_4 *i.e.* 50% RDF. Increasing levels of fertility in intercrop soybean significantly increases the seed yield of soybean (Meena *et al*., 2006). As soybean respond well to the more phosphorous application so the highest value for all the growth parameters better with 75 kg P_2O_5 (applies under 125% RDF) than 30 kg P_2O_5 (Applied under 50% RDF).

From the investigation it could be concluded that the intercropping of maize with soybean was found to be more beneficial than the sole planting of maize in terms of plant growth as well as yield. Maize+soybean, 2:2 and 2:4 replacement series showed greater fertilizer use efficiency, good chlorophyll content over rest of the cropping arrangements in maize. However in case of soybean sole crop was better performer. Soybean in replacement series performed better than additive series.

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