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Allelopahtic effect of summer sunflower on growth and yield of succeeding *kharif* mungbean (*Vigna radiata* L. Wilczek) under varied sowing periods

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Abstract: Field experiment was conducted during *kharif* season 2014 at Main Agricultural Research Station, UAS, Dharwad to study the allelopahtic effect of summer sunflower on growth and yield of succeeding *kharif* mungbean (*Vigna radiata* L. Wilczek) under varied sowing periods**.** Significantly higher seed yield of mungbean was obtained in *kharif* mungbean sown in previously summer fallow land (CS_2-716 kg ha^{-1}) compared to *kharif* mungbean sown in previously summer sunflower grown land (CS_1-593 kg ha^{-1}). Among the sowing periods, the crop sown after one week of harvest of summer sunflower (D_1) was recorded significantly higher seed yield (D_1-904 kg ha^{-1}) over other sowing periods except two weeks after harvest of summer sunflower (D_2-837 kg ha^{-1}) with which it was on par. This was followed by mungbean sown after three weeks of harvest of sunflower (D_3-726 kg ha^{-1}). The interaction effect of *kharif* mungbean sown after summer fallow at the date of T_1 (CS_2D_1-1038 kg ha^{-1}) was recorded significantly superior over other treatment combinations.

Key words: Allelopathy, Mungbean, Residue, Sunflower

Introduction

Allelopathy is one such phenomenon that has been observed in the crop lands since centuries. It plays a major role in natural ecosystems by determining vegetation pattern, plant dominance, succession and biodiversity, preventing seed decay and causing seed dormancy. Further, allelopathy has a potential role in agricultural ecosystems (Singh *et al.,* 2001). Sunflower (*Helianthus annuus* L.) is a strongly allelopathic, thermo and photo-insensitive plant. Hence, it can be grown round the year in sub-tropics. Therefore, it fits well in the multiple cropping systems of these regions. It is an annual oleaginous plant native to the Americas and it has allelopathic activity against some crops and weeds (Bogatek *et al.,* 2006). The allelochemicals released largely by the plant residues that are left in the fields after the harvest of crops. Crop residues of sunflower produce harmful effects on the germination and growth of subsequent crops (Azania *et al.,* 2003) Presently in India, sunflower is cultivated on an area of 8.20 lakh ha with the total production of 5.80 lakh tonnes and an average productivity of 707 kg ha^{-1} during 2012-13. In Karnataka, it is grown in area of 4.30 lakh ha with a production of 2.64 lakh tonnes and an average productivity of 613 kg ha^{-1} (Anon., 2013).

Mungbean or greengram (*Vigna radiata* L. Wilczek) is one of the important pulse crops in south and south-east Asia. In India, it is the third most important pulse crop after Bengal gram and pigeonpea. In India, it is covering an area of 3.53 m ha with a total production of 1.2 million tonnes and an average productivity of 340 kg ha^{-1}. In Karnataka, it occupies an area of about 0.369 m ha with a total production of 0.042 million tonnes and an average productivity of only 231 kg ha^{-1} (Anon., 2013). It is observed that there is reduction in the yield of *kharif* mungbean by the residual effect of summer sown sunflower. To address the issue that summer sunflower has residual effect on *kharif* mungbean crop, to know the per cent yield reduction in *kharif* mungbean by the residual/allelopathic effect of *rabi/* summer sunflower and optimization of interval between sowing of mungbean and harvesting of sunflower to have minimum allelopathic effect.

Material and methods

Field experiment was conducted to study the allelopathic effect of summer sunflower on *kharif* mungbean under varied sowing periods in vertisol. Sowing of *kharif* mungbean was taken up immediately after harvest of summer sunflower and followed by weekly interval.

A field experiment was conducted during *kharif*-2014 at Main Agricultural Research Station, Dharwad. The soil of experimental site was medium black clay soil. The composite soil sample of experimental area was collected before sowing and analyzed for important physical and chemical properties. The experimental site was low in nitrogen (253.4 kg ha^{-1}), medium in phosphorous (27.7 kg ha^{-1}) and high in potash (325.8 4 kg ha^{-1}). Experiment was laid out in a split plot design replicated thrice with different cropping system in main plots and sowing periods in sub plots. The net plot size was 3.0 m × 2.6 m (7.8 m^2). Two cropping systems (*kharif* mungbean sown after harvest of summer sunflower grown plot and *kharif* mungbean sown after summer fallow) were used in the study and sowing was done as per sowing date treatments (14th, 21th, 28th June, 5th, 12th and 19th July) designated as CS_1D_1 to CS_2D_6, respectively. The annual rainfall received during 2014 was 962.20 mm distributed in 69 rainy days. The total rainfall received during the *kharif* mungbean crop period (June-October, 2014) was 633.5 mm distributed in 49 rainy days. The mean monthly maximum temperature ranged from 27.0°C (July) to 30°C (October). Whereas, mean monthly minimum temperature ranged from 19°C (October) to 21.6°C (June). The mean monthly relative humidity was highest during July (89%) and ranged between 71 per cent (October) and 89 per cent (July) during cropping period. At

harvest, five plants per plot were sampled, oven dried at 70°C (48 hours) for complete drying, then pods were picked from the plants, counted and threshed for seeds. Seeds were cleaned and weighed for grain yield plant^{-1}. For statistical analysis data were analyzed using analysis of variance and means were compared using critical difference at the 5 per cent probability (Gomez and Gomez, 1984).

Results and discussion

Data pertaining to growth indices, yield and yield attributing characters of mungbean furnished in the Table 1 and 2.

Effect of cropping systems on growth and yield of mungbean

Kharif mungbean sown in previously summer fallow land recorded significantly higher seed yield (714 kg ha^{-1}) and haulm yield (1630 kg ha^{-1}) than *kharif* mungbean sown in previously summer sunflower grown plot (593 kg ha^{-1} and 1395 kg ha^{-1}, respectively). The increase in seed yield of CS_2 over CS_1 was to an extent of 16.94 and 14.41 per cent. This increase was due to increase in the growth and yield parameters of mungbean in CS_2 which was resulted in significantly higher number of pods (13.31) and higher number of seeds pod^{-1} (11.07) than CS_1 (Table 1). Yield is the net result of various interactions *i.e.,* soil characters, weather parameters, inter and intra plant competition and various metabolic and biochemical interactions taking place throughout the plant growth. Reduction in the *sunflower-mungbean* sequence was mainly due to allelopathic effect of sunflower on succeeding mungbean crop. Sunflower is the donor of allelopathic compounds, which affect acceptor plants via changes in many physiological processes and that these changes, being mostly statistically significant, showed a dose and time dependent relation. Allelopathic agents influence the plant growth through the following physiological processes *viz.,* cell division and cell elongation, phytohormal induced growth, membrane permeability, mineral uptake, availability of soil phosphorus and potash, gas exchange and process of photosynthesis, respiration, protein synthesis and changes in lipid and organic acid metabolism, inhibition of porphyrin synthesis, stimulation or inhibition of certain specific enzymes, corking and clogging of xylem elements, conductance of water through stem interior water relationships and miscellaneous (Al-Saadawi *et al.,* 2011; Azania *et al.,* 2003).

The yield parameters were directly correlated with the growth parameters. *Kharif* mungbean sown in previously summer fallow land (CS_2) recorded significantly higher plant height (57.91 cm), number of branches per plant (8.78), LAI (2.76) and dry matter production (9.48 g plant^{-1}) as compared to kharif mungbean sown in previously summer sunflower grown plot (52.41, 8.36, 2.58 and 8.96 g plant^{-1}, respectively) (Table 2). This was mainly due to the allelochemicals produced by the sunflower residue in that rhizosphere soil either by volatilization, leaching and decomposition of sunflower plant residues (Ghafar *et al.,* 2000; Kupidlowska *et al.,* 2006).These produced allelochemicals inhibited the germination and growth parameters of mungbean, probably by affecting the cell division and elongation process that were very important at this stage or by interfering with enzymes involved in the mobilization of nutrients necessary for germination (Batish *et al.,* 2002; Azania *et al.,* 2003). They also decreased the carbon absorption and suppressed the photosynthesis, which resulted in stunted growth of mungbean.

Effect of sowing periods on growth and yield of mungbean

Among sowing periods, the crop sown after one week of harvest of sunflower recorded significantly higher seed yield (D_1-904 kg ha^{-1}) over other sowing periods except two week after harvest of sunflower (D_2-837 kg ha^{-1}) with which it was

Table 1. Yield and yield attributing characters of mungbean as influenced by different cropping systems and sowing periods

Treatment	Number of pods per plant			Number of seeds per pod			Seed yield (kg/ha)			Haulm yield (kg/ha)		
	CS_1	CS_2	Mean	CS_1	CS_2	Mean	CS_1	CS_2	Mean	CS_1	CS_2	Mean
D_1	13.93	17.11	15.52	11.62	12.19	11.91	770	1038	904	1575	2049	1812
D_2	13.23	16.72	14.98	11.42	11.97	11.70	731	944	837	1533	1972	1753
D_3	11.03	13.84	12.44	10.74	11.21	10.98	660	793	726	1478	1741	1610
D_4	10.11	11.78	10.94	10.33	10.70	10.51	564	631	598	1351	1495	1423
D_5	9.78	10.26	10.02	10.23	10.31	10.27	430	461	446	1249	1315	1282
D_6	9.72	10.15	9.94	9.99	10.06	10.03	412	428	420	1182	1209	1195
Mean of CS	11.30	13.31		10.71	11.07		593	716		1395	1630	

For comparing means of	S.Em±	C.D. (P = 0.05)	S.Em±	C.D. (P = 0.05)	S.Em±	C.D. (P = 0.05)	S.Em±	C.D. (P = 0.05)
Different cropping system (CS)	0.13	0.80	0.06	0.34	20.1	120.4	21.5	130.6
Sowing period of mungbean (D)	0.17	0.51	0.07	0.22	23.03	69.11	24.3	74.3
Interaction- (CS x D)	0.25	0.73	0.10	NS	31.2	95.47	32.1	97.26

CS : Different cropping systems (CS)
CS_1 : *Kharif* mungbean sown in previously summer sunflower grown plot
CS_2: *Kharif* mungbean sown in previously summer fallow land

D : Sowing period of mungbean
D_1 : One week after harvest of sunflower (14th June)
D_2 : Two weeks after harvest of sunflower (21th June)
D_3 : Three weeks after harvest of sunflower (28th June)
D_4: Four weeks after harvest of sunflower (5th July)
D_5: Five weeks after harvest of sunflower (12th July)
D_6: Six weeks after harvest of sunflower (19th July)

DAS: Days after sowing NS: Non significant

on par. Mungbean crop sown after one week of harvest of sunflower (14th June) recorded significantly higher seed yield (904 kg ha^{-1}) when compared to crop sown after two, three, four, five and six weeks of harvest of sunflower (D_2-837 kg ha^{-1}, D_3-726 kg ha^{-1}, D_4-598 kg ha^{-1}, D_5-446 kg ha^{-1} and D_6-420 kg ha^{-1}, respectively). The crop sown after one week after harvest of sunflower registered 8, 19.62, 33.84, 50.66 and 53.53 per cent higher seed yield over two, three, four, five and six weeks after harvest of sunflower. The higher seed yield obtained in early sown crop is attributed to higher soil moisture during cropping period due to receipt of 242.20 mm rainfall during July. This coincides with the flowering and pod formation stage of early sown crop (Table 1). These results were in agreement with the finding of Narwal *et al.* (1999a).

The value of growth parameters like leaf area index, dry matter production plant^{-1} were also significantly higher in early sown crop which were responsible for higher value of yield components ultimately resulting in increased seed yield ha^{-1}. This was mainly due to the leaf area index at 60 DAS in early sown crop (D_1-3.04) was significantly higher than the crop sown after two, three, four, five and six weeks of harvest of sunflower (2.96, 2.76, 2.52, 2.40 and 2.34, respectively) (Table 2). Thus, the higher values of LAI in early sown crop resulted in increased production of photosynthates contributing to higher dry matter production.

The dry matter production at harvest in early sown crop was 10.41 g plant^{-1} (Table 2) which was significantly higher than crop sown after two, three, four, five and six weeks after harvest of sunflower (10.21, 9.42, 8.96, 8.36 and 7.97, respectively). This might be due to cultivated sunflower had retained the genetic information necessary for allelochemical production; these observations are good evidence of sunflower allelopathic potential and suggest that appropriate management strategies can be used to successfully exploit sunflower allelopathy. The results were corroborated with the findings of Nasira *et al.,* 2000, Bogatek *et al.,* 2006 and Al-Saadawi *et al.,* 2011 and they reported that growth of linseed, mustard and wheat inhibited by preceding sunflower residue incorporation, respectively.

Interaction effect of cropping system and sowing periods on growth and yield of mungbean

In the present investigation, the interaction effect of *kharif* mungbean sown after summer fallow at the date of D_1 (CS_2D_1) was noticed significantly higher seed yield (1038 kg ha^{-1}) as compared to other treatment combinations except *kharif* mungbean sown after summer fallow at the date of D_2) (CS_2D_2-944 kg ha^{-1}) with which it was on par. However, the lowest seed yield was recorded in *kharif* mungbean sown after six weeks of harvest of summer sunflower (CS_1D_6-412 kg ha^{-1}) as compared to other treatment combinations. The increase in yield might be due to better manifestation of yield attributing characters like number of pods plant^{-1} (17.11), seeds pod^{-1} (12.19) and seed yield plant^{-1} (10.46 g) which contributed to the higher seed yield (Table 1).

The interaction effects of *kharif* mungbean sown after one week of harvest of summer sunflower recorded significantly lower seed yield (CS_1D_1-770 kg ha^{-1}) as compared to other treatment combinations except *kharif* mungbean sown after two weeks of harvest of summer sunflower (CS_1D_2-731 kg ha^{-1}) with which it was on par. This was mainly due to allelochemical produced by the sunflower plant residues.

which were metabolically active in plants and microorganisms, their biosynthesis and biodegradation play a key role in the ecophysiology of the organism in which they occur (Kupidlowska *et al.,* 2006). Some of them are accumulated at various stages of growth, while, accumulation of some compounds depends upon season.

Table 2. Growth and growth parameters of mungbean as influenced by different cropping systems and sowing periods

Treatment	Plant height (cm)			No. of branches per plant			Leaf area index (LAI at 60 DAS)			Dry matter production (g plant^{-1})		
	CS_1	CS_2	Mean	CS_1	CS_2	Mean	CS_1	CS_2	Mean	CS_1	CS_2	Mean
D_1	61.25	70.25	65.75	8.90	9.43	9.17	2.91	3.18	3.04	9.90	10.91	10.41
D_2	60.43	68.07	64.25	8.76	9.30	9.03	2.83	3.10	2.96	9.72	10.69	10.21
D_3	56.48	62.99	59.74	8.54	9.03	8.79	2.62	2.89	2.76	9.22	9.62	9.42
D_4	49.99	55.96	52.98	8.16	8.82	8.49	2.42	2.62	2.52	8.79	9.12	8.96
D_5	44.20	46.57	45.39	8.00	8.27	8.13	2.36	2.43	2.40	8.20	8.53	8.36
D_6	42.11	43.61	42.86	7.77	7.83	7.80	2.33	2.36	2.34	7.94	8.00	7.97
Mean of CS	52.41	57.91		8.36	8.78		2.58	2.76		8.96	9.48	

For comparing means of	S.Em±	C.D. (P = 0.05)	S.Em±	C.D. (P = 0.05)	S.Em±	C.D. (P = 0.05)	S.Em±	C.D. (P = 0.05)
Different cropping system (CS)	0.13	0.80	0.018	0.111	0.007	0.041	0.03	0.19
Sowing period of mungbean (D)	1.49	4.40	0.043	0.128	0.027	0.080	0.07	0.20
Interaction- (CS x D)	2.11	6.22	0.061	0.181	0.038	0.112	0.10	0.28

CS : Different cropping systems (CS)

CS_1 : *Kharif* mungbean sown in previously summer sunflower grown plot

CS_2: *Kharif* mungbean sown in previously summer fallow land

D : Sowing period of mungbean

D_1 : One week after harvest of sunflower (14th June)

D_2 : Two weeks after harvest of sunflower (21th June)

D_3 : Three weeks after harvest of sunflower (28th June)

D_4: Four weeks after harvest of sunflower (5th July)

D_5: Five weeks after harvest of sunflower (12th July)

D_6: Six weeks after harvest of sunflower (19th July)

DAS: Days after sowing NS: Non significant

As there was delay in the sowing period in the *kharif* mungbean followed (CS_1) the impact of allelopathy decreases exponentially and at later period of sowing, there was no significant difference in the yield of mungbean in treatment combinations such as *kharif* mungbean sown after five and six week of harvest of summer sunflower (CS_1D_5 and CS_1D_6, respectively) (Table 2). Similar findings were reported by Narwal *et al.* (1999a), the phytotoxicity of sunflower biomass persisted in soil upto 4-5 weeks after soil incorporation. These results indicated that sunflower plants released and accumulated as phytotoxins in the soil which adversely affected the succeeding test crops. The performance of crop in different cropping system was exceptionally well in terms of plant vegetative growth and pod setting when the crop was sown after one week of harvest of sunflower (D_1) as compared to other sowing periods. There was significant difference between the cropping systems in respect of grain yield in all the sowing periods except six weeks after harvest of sunflower.

Conclusion

From the present investigation it was concluded that by providing 5 to 6 weeks gap in between summer sunflower and *kharif* mungbean, it will help in the reduction of the allelochemicals and which will provide an ambient growth condition for the succeeding crops.

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