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Assessment of yield loss with special reference to planting dates and their influence on diseases of sesame (*Sesamum indicum* L.)

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Abstract
Sesame crop raised in rainy season is prone to soil moisture stress and vagaries of rainfall due to unpredictable droughts / dry spells *i.e.* uncertainty of rain water availability, the swings in the onset, continuity and withdrawal pattern of monsoon make crop production more risky in rainfed farming areas. The experiments was laid out to study the severity of foliar diseases of sesame and their effect on yield. The results of the experiments over the seasons indicated that the percent disease index of *Cercospora* in sesame planted during third week of June was 26.25 and 34.69, second week of July was 25.01 and 31.81 and fourth week of July was 34.06 and 40.97. Whereas, bacterial leaf spot of sesame sown during third week of June was 28.86 and 39.96, second week of July 19.35 and 22.95 and fourth week of July recorded 15.65 and 24.90, powdery mildew of sesame during third week of June was 17.16 and 22.63, second week of July was 24.81 and 34.53 and fourth week of July recorded 18.13 and 25.33 and the incidence of *Macrophomina* stem and root rot was in the range of 62.90 and 85.20 and 65.36 and 93.25 under protected and unprotected conditions *respectively*. The average yield of 8.08 q/ha was recorded in protected as compared to 4.42 q/ha under unprotected conditions with an yield loss of 45.29% during first date of sowing. Our findings over the four seasons clearly suggested third week of June is preferable planting date for tolerant reaction for foliar disease of sesame.

Keywords: Bacterial leaf spot, *Cercospora* leaf spot, *Macrophomina* stem and root rot, planting dates, powdery mildew, yield loss

Introduction
Sesame (*Sesamum indicum* L.), a member of the order Tubiflorae belongs to family *Pedaliaceae* is an ancient oil seed known to humankind, sesame seeds have been widely employed in culinary as well as in traditional medicines for their nutritive, preventive, and curative properties [20]. Among the sesame growing countries in the world, India ranks first in area. India is the largest exporter of sesame. Sesame is described as the "Queen of oilseeds" because of its high oil content (38-54%), protein (18-25%), calcium, phosphorus, oxalic acid and excellent qualities of the seed oil and meal [14]. Sesame oil also contains high level of unsaturated fatty acids which has a reducing effect on the plasma cholesterol [2]. The productivity of Sesame is low due to its low harvest index, indeterminate growth habit, shattering, susceptibility to pests and diseases [1]. In Karnataka sesame is cultivated with an area of 0.35 lakh hectares and annual production of 0.31 lakh tonnes with a productivity of 924 kg/ha [8]. Among the several limiting factors for successful sesame production. The main constraint for the low productivity of this crop is due to severe outbreak of various fungal stem and root rot of sesame (*Macrophomina phaseolina*), *Alternaria* leaf spot (*Alternaria sesami*, Powdery mildew (*Leveillula taurica*), *Cercospora* leaf spot (*Cercospora sesamicola*), Bacterial leaf spot (*Ps. syringae pv. sesami*), viral and phytoplasma diseases. Environmental factors play an important role in development of foliar diseases on sesame. Temperature (maximum and minimum) and relative humidity play a major role in the growth of the pathogen and disease development. However there is lack of precise information on the influence of environmental factors on the development of foliar diseases on sesame [6]. Yield loss due to diseases is one of the major constraints. Systematic studies on estimation of loss in yield have not been worked out but its damage to the crop is reported to occur in India [5]. Among the foliar diseases, *Cercospora* leaf spot caused by *Cercospora sesamicola*, powdery mildew, bacterial leaf spot and *Macrophomina* stem and root rot are the most economically

important diseases of sesame in almost all the production areas. The crop is susceptible at all stages of the growth [17, 3] and causes heavy economic loss [19]. Therefore, the present investigation was undertaken to know the severity of sesame foliar diseases and their effect on yield and association of seed mycoflora.

Materials and Methods

i) Planting material and experimental site

A susceptible variety DSS-9 was used as planting material both under protected and unprotected situations for four seasons to investigate the suitable planting date to manage foliar diseases and to obtain optimum yield in Sesame. Experiments were conducted at All India Co-ordinated Research Project on Sesame and Niger, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *Kharif* 2014 to 2017. The crop was sown at different sowing intervals with a plot size of 3.0 m x 2.4 m by following recommended Agronomic practices. Fungicides *viz.*, Carbendazim @ 0.1% and combi product (Tebuconazole 50% + Trifloxistrobin 25% WG) @ 0.05% were sprayed at 15 days intervals and control (unprotected) was maintained to study the effect of disease severity on yield.

ii) Assessment of foliar diseases

Assessment of severity of foliar diseases both under protected and unprotected plots were recorded at weekly intervals. The observations for the severity of *Cercospora*, Bacterial leaf spot and powdery mildew were recorded using 0-5 scale [10] presented in (Table. 1)

Table 1: Disease rating scale

Disease grade	Description	Disease Reaction
0	No infection	Immune
1	1-10% of leaf area infected	Highly Resistant
2	11-25% of leaf area infected	Moderately Resistant
3	26-50% of leaf area infected	Moderately Susceptible
4	51-70% of leaf area infected	Susceptible
5	>70% of leaf area infected	Highly Susceptible

The percent disease index for *Cercospora* leaf spot, Bacterial leaf spot and powdery mildew was calculated by using formula [11].

$$\text{Percent disease index} = \frac{\text{Sum of numerical ratings}}{\text{Total number of leaves scored}} \text{ X } \frac{100}{\text{Maximum grade}}$$

iii) Assessment of *Macrophomina* stem and root rot incidence

Percent disease incidence was recorded at physiological maturity for *Macrophomina* stem and root rot under protected and unprotected plots. The percent disease incidence was calculated by formula

$$\text{Percent disease incidence} = \frac{\text{Total number of plants infected}}{\text{Total number of plants}} \text{ X } 100$$

iv) Estimation of yield loss

The estimation of yield loss due to sesame diseases was carried out by comparing the yield under protected condition by Spray of Carbendazim @ 0.1% and combi product (Tebuconazole 50% + Trifloxistrobin 25% WG) @ 0.05% for *Cercospora sesamicola* and powdery mildew [12] and *Macrophomina* stem and root rot. Whereas, (Streptocyclin + copper oxychloride) @ 0.05% was used for managing bacterial leaf spot of sesame. The yield obtained under protected situation was compared with the yield of unprotected condition and percent yield loss was calculated by formula

$$\text{Percent yield loss} = \frac{\text{Yield of protected plot} - \text{Yield of unprotected plot}}{\text{Yield of protected plot}} \text{ X } 100$$

v) Detection of seed mycoflora

For enumeration of seed mycoflora associated with sesame seeds were studied by following Blotter paper technique. Fifteen randomly selected seeds were placed on sterilized blotting paper in Petriplates. The plates were incubated in BOD incubator at 25 ^{0}C for 7 days. The observations on seed mycoflora associated with sesame seeds were identified under protected and unprotected plots.

Results

i) Disease severity

Investigation of suitable planting dates in the management of sesame diseases and to obtain optimum yield in sesame an experiment was conducted using a susceptible variety DSS-9. The results of the experiment conducted over seasons from *kharif* 2014 to 2017 indicated that the crop sown during third week of June recorded 26.25 and 34.69, second week of July recorded 25.01 and 31.81 and fourth week of July recorded 34.06 and 40.97. The average disease severity of *Cercospora sesamicola* leaf spot was 28.44 and 35.82 percent disease index under protected and unprotected situations respectively. *i.e*, Third week of June (Fig. 1). The severity of bacterial leaf spot of sesame during third week of June was 28.86 and 39.96, second week of July 19.35 and 22.95 and fourth week of July recorded 15.65 and 24.90. The average disease severity was 21.28 and 29.27 percent disease index for bacterial leaf spot under protected and unprotected situations respectively. The severity of powdery mildew of sesame during third week of June was 17.16 and 22.63, second week of July 24.81 and 34.53 and fourth week of July recorded 18.13 and 25.33. The average disease severity was 20.03 and 27.49 percent disease index under protected and unprotected situations respectively. The incidence of *Macrophomina* stem and root rot was in the range of 62.90 and 85.20 and 65.36 and 93.25.The average incidence was 73.41 and 77.50 under protected and unprotected conditions respectively (Table. 2 and Fig. 2).

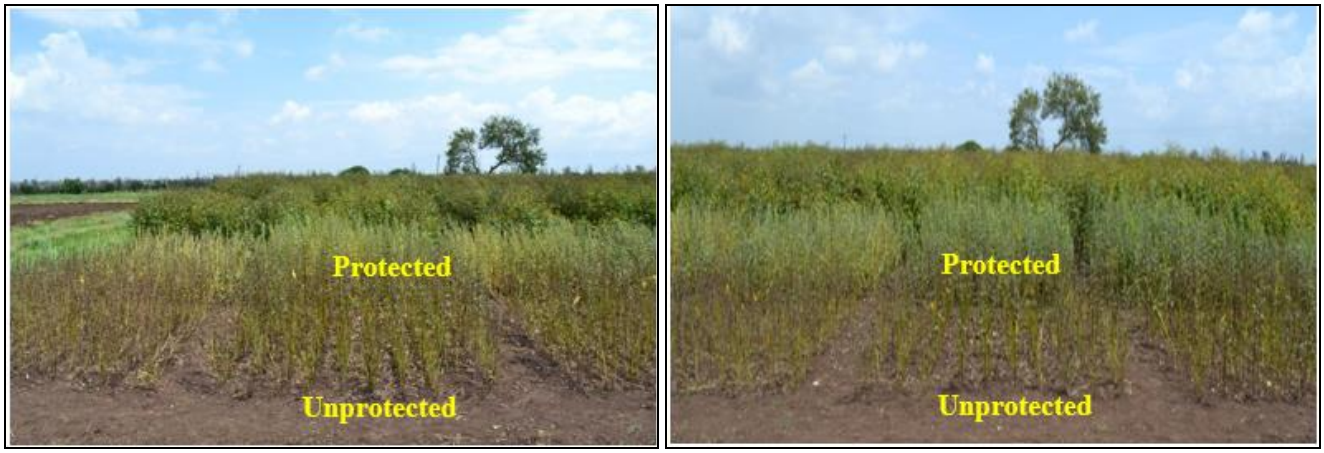
ii) Yield loss due to sesame diseases

The sesame crop sown during *Kharif* 2015 suffered due to severe moisture at seedling and capsule stage favorable for the powdery mildew followed by severe outbreak of *Macrophomina* stem and root rot which leads to premature opening of capsules, chaffy seeds and considerable reduction in yield. The average yield of 8.08 q/ha was recorded in protected as compared to 4.42 q/ha under unprotected conditions with an yield loss of 45.29% during first date of planting. The considerable reduction in yield was recorded in subsequent dates of planting indicating 49 to 50% yield loss. The average yield irrespective of date of planting was 5.62 and 3.29 q/ha under protected and unprotected sesame plots (Table. 3 and Fig. 3).

iii) Seed mycoflora

The seed mycoflora associated with sesame seeds were studied using Blotter paper technique under laboratory. The

seed mycoflora associated were *Cercospora sesamicola* and *Alternaria solani* under protected condition. Whereas, under unprotected *Aspergillus niger*, *Pencillium sp* and *Alternaria sp* were found predominant (Fig. 4).



Third week of June sowing

Second week of July sowing

Fourth week of July sowing

Fig 1: Severity of foliar diseases of sesame at different planting dates under protected and unprotected experimental plots

Table 2: Influence of planting dates on severity of Sesame diseases

Planting intervals	*Cercospora sesamicola* Percent Disease Index (PDI)								Mean	
	Kharif-2014		*Kharif*- 2015		*Kharif* -2016		*Kharif* -2017			
	P	UP	P	UP	P	UP	P	UP	P	U.P
Third week of June	29.00	34.00	traces	traces	38.10	54.20	11.66	15.87	26.25	34.69
Second week of July	22.70	26.70	traces	traces	34.10	32.00	18.23	36.73	25.01	31.81
Fourth week of July	24.20	28.00	traces	traces	18.40	36.73	55.60	62.20	34.06	40.97
Mean	26.63	28.23	-	-	30.20	40.97	28.47	38.26	28.44	35.82
Bacterial leaf spot Percent Disease Index (PDI)										
Third week of June	26.50	26.90	40.00	48.00	20.10	45.80	traces	traces	28.86	39.96
Second week of July	22.30	25.20	traces	traces	16.40	20.70	traces	traces	19.35	22.95
Fourth week of July	24.10	34.20	traces	traces	7.20	15.60	traces	traces	15.65	24.90
Mean	24.30	28.79	-	-	14.56	27.36	-	-	21.28	29.27
Powdery mildewPercent Disease Index (PDI)										
Third week of June	23.30	28.40	15.00	20.00	24.60	32.80	5.75	9.34	17.16	22.63
Second week of July	25.00	37.00	40.95	59.90	22.80	27.00	10.50	14.25	24.81	34.53
Fourth week of July	31.50	40.00	drooping	drooping	14.00	23.70	8.90	12.30	18.13	25.33
Mean	26.60	35.13	27.97	39.95	20.46	27.83	8.38	11.96	20.03	27.49
***Macrophomina* stem and root rot Percent Incidence (PDI)**										
Third week of June	Nil	Nil	93.90	90.73	Nil	Nil	31.90	40.00	62.90	65.36
Second week of July	Nil	Nil	86.00	93.20	Nil	Nil	84.40	93.30	85.20	93.25
Fourth week of July	Nil	Nil	88.70	85.60	Nil	Nil	55.60	62.20	72.15	73.90
Mean	-	-	89.53	89.84	-	-	57.30	65.16	73.41	77.50

Table 3: Yield loss assessment due to Sesame diseases

Planting intervals	Yield q/ha								Mean yield q/ha		Percent yield loss over unprotected
	Kharif- 2014		*Kharif*- 2015		*Kharif* -2016		*Kharif*- 2017				
	P	UP	P	UP	P	UP	P	UP	P	UP	
Third week of June	11.80	4.30	9.70	5.75	5.45	4.62	5.40	3.04	8.08	4.42	45.29
Second week of July	7.00	2.60	7.10	4.00	6.89	3.64	2.69	1.86	5.92	3.02	49.00
Fourth week of July	4.10	1.30	4.40	3.35	1.12	0.47	1.92	0.62	2.88	1.44	50.00
Mean	7.63	2.73	7.06	5.03	4.48	3.57	3.33	1.84	5.62	3.29	41.45
Sowing intervals	**B:C Ratio**										**Percent benefit over control**
Third week of June	6.07	2.39	4.67	2.81	1.38	1.21	2.16	1.20	3.57	1.90	46.77
Second week of July	3.60	1.44	3.43	2.94	1.75	1.48	1.07	0.73	2.00	1.64	18.00
Fourth week of July	2.16	0.72	2.13	1.64	0.28	0.10	0.72	0.24	1.32	0.67	49.24
Mean	3.94	1.51	3.41	2.46	1.13	0.93	1.31	0.72	2.29	1.40	38.00
P- Protected UP - Unprotected											

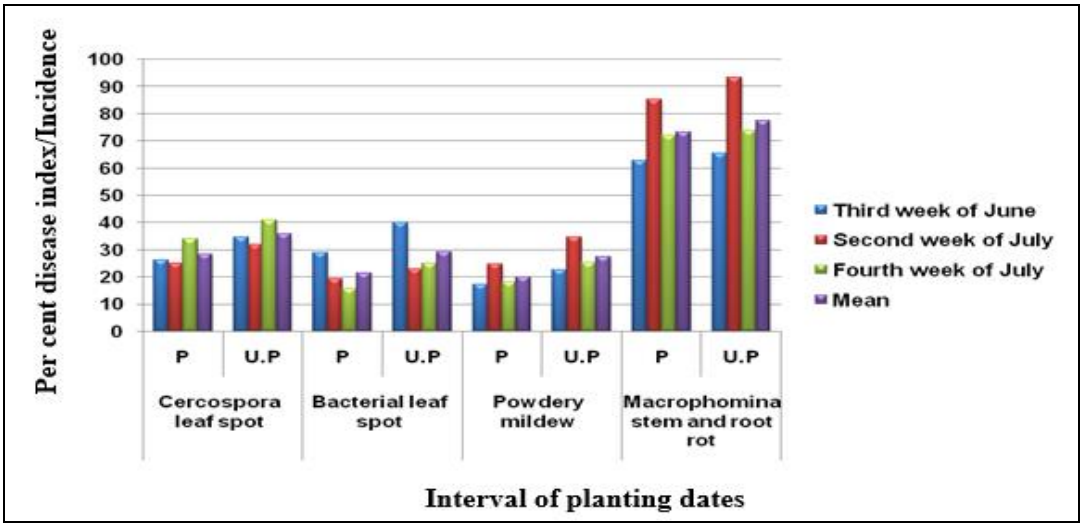


Fig 2: Per cent disease index/ incidence under protected and unprotected situations at different planting intervals

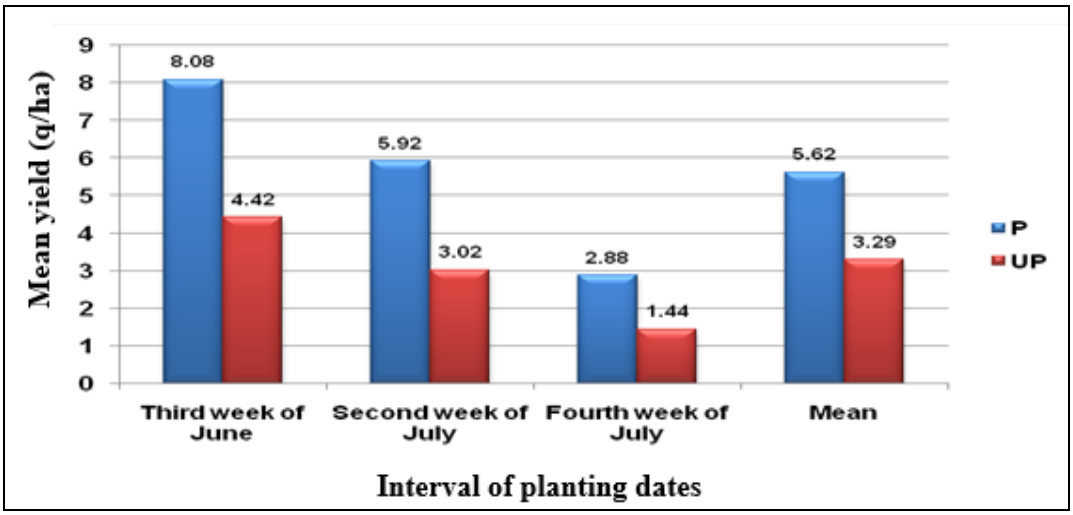


Fig 3: Seed yield under protected and unprotected situations at different planting intervals

Fig 4: Enumeration of mycoflora associated with sesame seeds

Discussion

Experimental results conducted over seasons from *kharif* 2014 to 2017 indicated that the crop sown during third week of June recorded 26.25 and 34.69, second week of July recorded 25.01 and 31.81 and fourth week of July recorded 34.06 and 40.97. The average disease severity of *Cercospora sesamicola* leaf spot was 28.44 and 35.82 percent disease index under protected and unprotected situations respectively. The average yield of 8.08 q/ha was recorded in protected as compared to 4.42 q/ha under unprotected conditions with an yield loss of 45.29% during first date of sowing. Reduction in yield loss due to *Cercospora* leaf spot was 5% in Assam and yield loss of 11-18% due to severe incidence of *Cercospora* leaf spot were reported [5, 13]. Similarly experiment in two seasons conducted and noted that *Cercospora* leaf spot of sesame in both the seasons had significantly reduced the grain yield [9]. Similar findings on Bacterial leaf spot was reported and concluded loss due to bacterial blight was 20-27% in India [18]. The severity of powdery mildew of sesame during third week of June was 17.16 and 22.63 recorded low disease index compared to second week of July 24.81 and 34.53 and fourth week of July 18.13 and 25.33. The average disease severity was 20.03 and 27.49 percent disease index under protected and unprotected situations respectively. The incidence of powdery mildew from 35-40 days after sowing and peak incidence at 65 to75 days after sowing [7] and sesame powdery mildew causes yield loss upto 25-50% due to defoliation [15]. The incidence of *Macrophomina* stem and root rot was in the range of 62.90 and 85.20 and 65.36 and 93.25. The average incidence was 73.41 and 77.50 under protected and unprotected conditions respectively. The present investigation of *Macrophomina* are in accordance with the findings of [4] who reported 50% yield loss in sesame due to *M. phaseolina* and estimated 50% losses in yield of maize due to *M. phaseolina* [16].

The average yield of 8.08 q/ha was recorded in protected as compared to 4.42 q/ha under unprotected conditions with an yield loss of 45.29% during first date of planting. The considerable reduction in yield was recorded in subsequent dates of planting indicating 49 to 50% yield loss. The average yield irrespective of date of planting was 5.62 and 3.29 q/ha under protected and unprotected sesame crop. Similarly symptoms of Stem rot and *Cercospora* leaf spot yield losses ranging from 10 to 75% and 5 to 50% respectively. A little yield reduction 5% was caused by Bacterial leaf spot in Farmers field of Myanmar [21].

Conclusion

It is noteworthy that, from present investigation on assessment of yield loss in sesame due to sesame diseases in sesame over the years exhibited that the percent disease index of *Cercospora* and bacterial leaf spots, powdery mildew and *Macrophomina* in sesame planted during third week of June was low compared to subsequent planting dates *viz.*, second week of July and fourth week of July. The average yield of 8.08 q/ha was recorded in protected as compared to 4.42 q/ha under unprotected conditions. Maximum cost benefit ratio was obtained for the crop planted during third week of June due to tolerant reaction of foliar diseases and economic yield.

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