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Research Note

Performance of improved sunflower populations for resistance to Alternaria leaf blight and productivity

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Abstract:
An experiment was conducted to evaluate the performance of two sunflower populations *viz.*, C_3 (three cycles of improvement through recurrent selection without pollen selection) and C_3G_3 (three cycles of improvement through recurrent selection with pollen selection) for their reaction to Alternaria leaf blight, seed yield and yield components. The C_3 and C_3G_3 populations were compared for mean and variances. The Kolmogorov-Smirnov (K-S) test indicated the significant differences among the populations for distribution. The frequency distribution revealed that the C_3G_3 population was skewed towards resistance with higher frequency of plants with lower PDI (per cent disease index) values compared to C_3 population. The C_3G_3 population showed significantly higher mean seed yield than C_3 population suggesting that in population improved with pollen selection, the selection response was better. The frequency distribution for seed yield, head diameter and volume weight revealed the presence of higher frequency of plants in C_3G_3 population with high yielding, larger heads with high volume weight.

Key words: Sunflower, pollen selection, recurrent selection, , *Alternaria* leaf blight

Sunflower (*Helianthus annuus* L.) is one of the most important source of edible oil in India. This crop has shown distinct superiority over other edible oilseed crops owing to its wider adaptability to different agro-climatic conditions, higher oil production per unit area, short duration, photoperiod insensitivity, high potential yield and ability to withstand drought compared to other rainfed crops particularly under delayed sown conditions. However, the crop is prone to several biotic and abiotic stresses. In India, the major problem of sunflower is its susceptibility to Alternaria leaf blight, which occurs, in epiphytotic forms (Reddy and Gupta, 1977; Hiremath *et al*., 1990). The disease is known to cause reduction in flower size, number of seeds per head, seed yield per plant, seed weight and also oil content (Wallace and Wallace, 1950; Acimovic, 1969; Reddy and Gupta, 1977; Allen *et al.*, 1983; Hiremath *et al.*, 1990). The loss in the yield level varies from 11.30 to 80.00 per cent depending on the extent of infection (Reddy and Gupta, 1977; Hiremath *et al.*, 1990). It is not practicable to control the disease using chemical fungicides at field level. Therefore, in built genetic resistance would be the most economic means of reducing yield losses in sunflower.

Attempts to identify resistance to Alternaria leaf blight in sunflower were made by several workers (Agrawat *et al.*, 1979; Shane *et al.*, 1981; Morris *et al.*, 1983; Shobha Rani and Ravikumar, 2002). However, only partial resistance is reported either in cultivated or in related species (Carson, 1985a and 1985b; Ravikumar *et al.*, 1995; Shobha Rani and Ravikumar, 2002). Kong *et al.* (1996) reported that, Alternaria leaf and stem blight resistance appears to be additive and only moderate gains can be expected by selection. To achieve high resistance to Alternaria leaf blight in sunflower, Ravikumar *et al.* (1995) and Kong *et al.* (1996) proposed recurrent selection and induced mutations. Therefore an attempt has been made to evaluate the performance of improved sunflower populations for resistance to Alternaria leaf blight and productivity.

The base population for populations under study was synthesized by random mating of five genotypes showing relatively less susceptibility to alternaria leaf blight (Acc. Nos. 180-47, 180-48, 875-3, 1229-4 and 1229-17). The base population was improved for resistance through recurrent selection with and without pollen selection. The base population was improved for three cycles and the population improved with pollen selection was considered as C_3G_3 and the population improved without pollen selection was considered as C_3. The C_3 and C_3G_3 populations were grown during *kharif* 2008 for evaluation in two replications. Each population was grown in a plot size of 150 sq. m per replication with a distance of 60 cm between rows and 30 cm between plants. Along all the borders and after every twenty rows susceptible check Morden was planted. All standard agronomic practices except fungicidal spray were followed to raise the crop. Three hundred plants each (150 per replication) in C_3 and C_3G_3 populations were randomly selected for recording observations on disease severity at two stages *viz.*, at flowering and at 15 days after first scoring, seed yield per plant and other characters such as days to flowering of individual plants, plant height, head diameter and volume weight.

Data collected on individual plants of each population were used to compare the populations. The mean, range, variance and coefficient of variation of each character were calculated for each population and the population means and variances were compared. The distribution of two populations was compared using K-S test (Kolmogorov-Smironov test), a non-parametric analysis. The chi-square (K-S test) test was conducted to compare the distribution of two populations by following standard procedure (Siegal and Castellan, 1988). The frequency distribution of plants for PDI at flowering, PDI at 15 days after flowering, head diameter, volume weight and seed yield based on inclusive method at class interval of 5, 6, 2, 3 and 10 days respectively were carried out separately for each population.

Recurrent selection is a cyclic process practicing reselection generation after generation, with intercrossing of selects to provide genetic recombination. The genetic attributes of leaf blight resistance in sunflower suggest that recurrent selection could be an appropriate and effective breeding method to improve resistance. However, this method is tedious and time consuming. The selection response is dependent on selection intensity and heritability. Both the parameters depend on screening of large number of individuals, which is not practicable. Therefore, it is necessary to seek alternative approaches to over come those problems. Ottaviano and Mulcahy (1986) suggested that the highest response to selection could be achieved by combining both gametophytic and sporophytic selection. In sunflower, population improvement through recurrent selection to accumulate quantitative traits like oil content and resistance to Alternaria leaf blight were attempted and found to be successful (Pustovoit and Khatnyanskii, 1985; Shabana, 1990; Mamonov; 1991; Vear *et al*., 1992; Shobha Rani, 2003). The populations improved by combining both sporophytic and gametophytic selection recorded significantly lower PDI values than that of the population improved by sporophytic selection alone. The estimates of mean, range, variance and coefficient of variation for Alternaria leaf blight (PDI) at two stages, head diameter, plant height, days to flowering, volume weight and seed yield per plant were determined in each population separately and the results are presented in Table 1.

The mean PDI values at flowering in C_3 (28.96 %) and C_3G_3 (28.75 %) populations were on par with each other. The range was from 3.33 to 77.77 in C_3 and 3.33 to 66.66 per cent in C_3G_3 population. The variance and coefficient of variation (CV) were high for PDI at flowering than for PDI at 15 days after flowering in both the populations. The population C_3G_3 recorded higher variance and CV (212.71 and 50.73) than C_3 (198.73 and 48.68).

The population C_3G_3 showed lower mean PDI value (50.18 %) compared to C_3 population (52.30 %) for PDI at 15 days after flowering. However, the difference was not significant. In population C_3, wider range was observed (20.00 to 92.21 %) than population C_3G_3 (13.33 to 82.22 %). The trait recorded higher variance and CV in C_3G_3 population (176.54 and 28.15), compared to C_3 population (163.13 and 24.42).

The C_3 and C_3G_3 populations were grown during *kharif* season of 2008. The *kharif* season is characterized by high relative humidity, rainfall and moderate temperatures, which were congenial for high incidence and development of Alternaria leaf blight in sunflower. The occurance of natural epiphytotic conditions has favored the appearance of disease during *kharif*. Three hundred plants each from C_3 and C_3G_3 populations were scored and the mean and variances were compared. The mean PDI values of C_3 and C_3G_3 populations did not differ significantly.

Infact, it was suggested to use more such cyclic selections to improve resistance. Shobha Rani (2003) also observed reduction in variability of the populations consequent to selection and intermating, which may result in decreased response to selection for resistance at later stages. Such decreased response to selection at later stages of population improvement was observed for tolerance to barley yellow dwarf virus after two cycles of recurrent selection by Baltenberger *et al.* (1998). The decreased response to selection in partial resistance might have resulted in non-significant differences between the mean values of two populations after 3rd cycle of improvement. Shobha Rani (2003) also observed reduction in differences between mean values of population improved with and without pollen selection at later stages.

The mean number of days taken for flowering in C_3G_3 population (56.77) was higher than C_3 population (55.87). However, the difference was not significant. The range was also higher in C_3G_3 population (49 - 67 days) compared to C_3

population (49 - 64 days). For this trait also, the C_3G_3 population showed higher variance (15.18) and CV (6.86) than C_3 population (8.99 and 5.37).

The mean plant height observed was significantly higher in C_3G_3 population (172.45 cm) than in C_3 population (170.45 cm). Wider range was observed for plant height in C_3G_3 population (91.00 to 250.00 cm) than in C_3 population (107.00 to 240.00 cm). The variance and CV were also high in C_3G_3 population (753.48, 15.91) compared to C_3 population (528.64 and 13.49).

The mean head diameter of C_3G_3 population (15.79 cm) was significantly higher than the mean head diameter of C_3 population (14.30 cm). The range observed in the C_3G_3 population was 8.50 to 28.00 cm, while the same was 6.50 to 23.40 cm in C_3 population. The C_3G_3 population showed higher variance (10.69) than C_3 population (9.97). However the CV was marginally higher in C_3 (22.08) than in C_3G_3 (20.69) population.

The C_3G_3 (34.36 g) and C_3 (34.69 g) populations did not differ much for the mean volume weight. The C_3 population showed wider range (17.58 to 49.33 g) for volume weight than C_3G_3 (25.20 to 47.83 g). The variance and CV were also higher in C_3 (25.47 and 14.86) than in C_3G_3 population (16.98 and 11.99).

The mean seed yield per plant was higher in C_3G_3 population (43.35 g) compared to C_3 population (37.74 g), with the range of 5.80 to 145.00 g and 3.70 to 105.30 g respectively. The C_3G_3 population recorded higher variance (494.32) than C_3 population (376.48). However both the populations recorded more or less same CV (51.29 for C_3 and 51.54 for C_3G_3).

The chi- square values of the K-S test (Kolmogorov-Smirnov test) have shown that the distribution of the two populations *viz*., C_3 and C_3G_3 were significantly different for the traits PDI at flowering, PDI at 15 days after flowering, head diameter, volume weight and seed yield (Table 2). The frequency distribution analysis for PDI at flowering, PDI at 15 days after flowering, head diameter, volume weight and seed yield was carried out in C_3 and C_3G_3 populations and are presented in Table 3 to 7.

In the present study, although the two populations did not differ for their mean values, the distributions of the two populations were compared. The K-S test indicated that the populations differed significantly for their distribution. The frequency distribution of genotypes clearly indicated that the C_3G_3 population is skewed towards lower PDI values resulting in more number of resistant plants compared to C_3 population. For example, 61 per cent plants of C_3G_3 had PDI less than 50 per cent while, in C_3 population only 37 per cent of plants had less than 50 per cent at 15 days after flowering. Such skewing of population towards resistance consequent to gametophytic selection was observed in sunflower by Chikkodi and Ravikumar (2000) and Shobha Rani (2003) and in other crops by Simon and Sandford (1986). The population improved through combining gametophytic and sporophytic selection had more number of resistant plants suggesting more scope for selection of resistant plants compared to C_3 population. However, the level of resistance achieved even after three cycles of improvement was not high. Therefore, it is suggested to practice more number of such selection and intermating to achieve high level of resistance. However, it is necessary to follow progeny evaluation before selecting of plants for intermating. The populations studied (C_3 and C_3G_3) also showed moderate to high variability for disease resistance suggesting further scope for improvement. It is reported that relatively long time is required for accumulation of partial and polygenic resistance (Jenkins *et al*., 1954). The repeated recurrent selection cycles ranging from 4 to 8 for improvement of partial resistance has been reported in other crops (Walker and Schmitthenner, 1984; Reinhold *et al.*, 1993). The variance and range of both C_3 and C_3G_3 population indicate that there is scope to further improve resistance in sunflower.

An advantage of population improvement through recurrent selection is that a large amount of genetic variability can be utilized and many traits can be simultaneously improved in the population (Jiang *et al*., 1994). There was significant increase in mean seed yield in C_3G_3 population compared to C_3 population. The C_3G_3 population also recorded significantly high variance than C_3 population. In both the populations, the selection of plants was made primarily for resistance to Alternaria leaf blight and secondly for seed yield. The results clearly showed that seed yield was more responsible to gametophytic and sporophytic selection. Assuming a few major genes associated with greater improvement in seed yield than resistance would be expected. Similar response for grain yield and heading date was observed in wheat (Avery *et al*, 1982) than disease resistance. The disease resistance being polygenic and partial and controlled by additive gene action, only moderate gains can be expected by selection for this trait (Kong *et al.*, 1996).

For some of the other important traits *viz.*, head diameter and plant height also, C_3G_3 recorded significantly high mean values. Shobha Rani

(2003) also reported such significant differences between the populations, improved with and without pollen selection.

The K-S test for seed yield, head diameter and volume weight revealed the presence of significant differences between C_3 and C_3G_3 populations with respect to distribution. It is evident from frequency distribution, that the population improved with pollen selection (C_3G_3) had more number of plants with higher seed yield, head diameter and volume weight. The shift in the frequency distribution in the desired directions could be due to selection pressure applied in the population. The seed yield is significantly associated with head diameter and volume weight. Therefore, the population which recorded higher response to selection for seed yield also showed better performance for important seed yield components like head diameter and volume weight. The selection for resistance to disease and seed yield simultaneously improved many other traits. Shobha Rani (2003) also observed simultaneous improvement in many traits in populations improved for seed yield. The pollen selection, not only resulted in more number of plants with less PDI and high seed yield, but also resulted in more number of plants with larger heads. Overall, the results clearly indicated that the population improved through gametophytic selection (C_3G_3) was performing better than population improved without gamete selection. By combining sporophytic selection with gametophytic selection, it is possible to enhance the effect of recurrent selection (Landy *et al*., 1989, Kovacs and Barbanas, 1992 and Chikkodi and Ravikumar, 2000). Therefore, the population improved through pollen selection forms the excellent material for further improvement of seed yield and Alternaria leaf blight resistance and to develop superior breeding lines. The results also indicated that large number of such cyclic selection should be attempted for further improvement.

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Table 1. Mean, range, variance and coefficient of variance (CV) for Per cent Disease Index (PDI), seed yield and yield components in C_3 and C_3G_3 populations in sunflower

Character	Population	Mean ± SE	Range	Variance	CV
Days to flowering	C_3	55.87±0.17[a]	49.00-64.00	8.99[a]	5.37
	C_3G_3	56.77±0.23[a]	49.00-67.00	15.18[b]	6.86
Plant height (cm)	C_3	170.45±1.33[a]	107.00-240.00	528.64[a]	13.49
	C_3G_3	172.45±1.58[b]	91.00-250.00	753.48[b]	15.91
Head diameter (cm)	C_3	14.30±0.18[a]	6.50-23.40	9.97[a]	22.08
	C_3G_3	15.79±0.19[b]	8.50-28.00	10.69[a]	20.69
Volume weight (g)	C_3	34.69±0.29[a]	17.58-49.33	25.47[a]	14.86
	C_3G_3	34.36±0.24[a]	25.20-47.83	16.98[b]	11.99
Seed yield per plant (g)	C_3	37.74±1.12[a]	3.70-105.30	376.48[a]	51.41
	C_3G_3	43.35±1.28[b]	5.80-145.00	494.32[b]	51.29
PDI at flowering	C_3	28.96±0.81[a]	3.33-77.77	198.73[a]	48.68
	C_3G_3	28.75±0.84[a]	3.33-66.66	212.71[a]	50.73
PDI at 15 days after flowering	C_3	52.30±0.74[a]	20.00-92.21	163.13[a]	24.42
	C_3G_3	50.81±0.77[a]	13.34-82.22	176.54[a]	28.15

C_3 :Three cycle of improvement with out pollen selection
C_3G_3 : Three cycle of improvement with pollen selection
Note: Values with the same superscript for any trait indicate that they do not differ significantly

Table 2. Kolmogorov-Smirnov test (K-S test) for distribution of C_3 and C_3G_3 populations for important traits

Character	Calculated Chi-square	Table Chi-square	Probability
PDI at flowering	22.00	16.81	< 0.01
PDI at 15 days after flowering	54.00	16.81	< 0.01
Head diameter (cm)	111.99	21.67	< 0.01
Volume weight (g/100 ml)	46.80	26.22	< 0.01
Seed yield per plant (g)	83.99	27.69	< 0.01

Table 3. Frequency distribution of plants for Per cent Disease Index (PDI) at flowering in C_3 and C_3G_3 populations in sunflower

PDI	Frequency %	
	C_3	**C_3G_3**
3.33 – 8.32	6.67	7.00
8.33 - 13.32	12.23	14.00
13.33 - 18.32	8.00	5.67
18.33 - 23.32	12.33	19.67
23.33 - 28.32	4.00	4.33
28.33 - 33.32	4.00	2.33
33.33 - 38.32	21.33	17.33
38.33 - 43.32	6.00	7.33
43.33 - 48.32	14.00	14.33
48.33 - 53.32	2.67	2.33
53.33 - 58.32	4.33	0.33
58.32 - 63.32	0.67	1.33
63.33 - 68.32	0.00	0.00
68.33 - 73.32	0.00	0.00
73.33 - 78.32	0.33	0.00

C_3 :Three cycle of improvement with out pollen selection
C_3G_3 : Three cycle of improvement with pollen selection

Table 4. Frequency distribution of plants for Per cent Disease Index (PDI) at 15 days after flowering in C_3 and C_3G_3 populations in sunflower

PDI	Frequency %	
	C_3	C_3G_3
13.33 - 19.32	0.00	0.67
19.33 - 25.32	1.67	2.33
25.33 - 31.32	1.67	3.67
31.33 - 37.32	11.67	9.67
37.33 - 43.32	7.67	9.00
43.33 - 49.32	14.67	18.00
49.33 - 55.32	17.33	18.00
55.33 - 61.32	20.00	14.67
61.33 - 67.32	15.00	15.00
67.33 - 73.32	7.33	10.00
73.32 - 79.32	2.33	3.67
79.33 - 85.32	0.00	1.00
85.33 - 91.32	0.33	0.00
91.33 - 97.32	0.33	0.00

C_3 :Three cycle of improvement with out pollen selection
C_3G_3 : Three cycle of improvement with pollen selection

Table 5. Frequency distribution of plants for head diameter in C_3 and C_3G_3 populations in sunflower

Head Diameter (cm)	Frequency %	
	C_3	C_3G_3
6.50 - 8.49	3.00	0.00
8.50 - 10.49	9.00	3.67
10.50 - 12.49	14.67	11.67
12.50 -14.49	25.33	18.00
14.50 -16.49	21.33	26.33
16.50 - 18.49	17.67	19.33
18.50 - 20.49	5.33	13.00
20.50 - 22.49	2.67	5.00
22.50 - 24.49	1.00	2.33
24.50 - 26.49	0.00	0.33
26.50 - 28.49	0.00	0.33

C_3 :Three cycle of improvement with out pollen selection
C_3G_3 : Three cycle of improvement with pollen selection

Table 6. Frequency distribution of plants for volume weight in C_3 and C_3G_3 populations in sunflower

Volume weight (g)	Frequency %	
	C_3	C_3G_3
10.00 - 12.99	0.33	0.00
13.00 - 15.99	0.00	0.00
16.00 - 18.99	0.33	0.00
19.00 - 21.99	0.00	0.00
22.00 - 24.99	2.33	0.00
25.00 - 27.99	6.33	6.67
28.00 - 30.99	14.00	14.33
31.00 - 33.99	20.33	25.67
34.00 - 36.99	25.33	27.00
37.00 - 39.99	16.00	19.00
40.00 - 42.99	9.67	4.67
43.00 - 45.99	4.00	2.00
46.00 - 48.99	1.00	0.67
49.00 - 51.99	0.33	0.00

C_3 :Three cycle of improvement with out pollen selection
C_3G_3 : Three cycle of improvement with pollen selection

Table 7. Frequency distribution of plants for seed yield per plant in C_3 and C_3G_3 populations in sunflower

Seed yield per plant (g)	Frequency %	
	C_3	C_3G_3
3.70 - 13.69	11.67	5.67
13.67 - 23.69	13.00	15.00
23.70 - 33.69	24.00	14.00
33.70 - 43.69	18.00	23.00
43.70 - 53.69	11.00	14.33
53.70 - 63.69	13.67	11.33
63.70 - 73.69	4.00	7.33
73.70 - 83.69	2.67	4.00
83.70 - 93.69	1.33	2.33
93.70 - 103.69	0.33	1.67
103.70 - 113.69	0.33	0.67
113.70 - 123.69	0.00	0.00
123.70 - 133.69	0.00	0.33
133.70 - 143.69	0.00	0.00
143.70 - 153.69	0.00	0.33

C_3 :Three cycle of improvement with out pollen selection
C_3G_3 : Three cycle of improvement with pollen selection