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Impact of genotypic mixture on soybean (*Glycine max*) pest population

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ABSTRACT

An experiment was conducted during rainy (*kharif*) seasons of 2018 and 2019 at the ICAR-Indian Institute of Soybean Research, Indore, and Madhya Pradesh to study the impact of genotypic mixture on soybean [*Glycine max* (L.) Merr.] pest population. A total of 16 soybean genotypes and 4 genotypic mixtures were evaluated for relative efficacy in management of insect-pests of soybean. Among the 20 treatments, the plots with genotypic mixtures had lowest population of *Spodoptera exigua* Hubner and at par with each other. In case of *Spodoptera litura* Fabricius, tussock moth, blue beetle and grey weevil management, a mixture of the genotypes JS-9560, JS-20-34, MAUS-47 and MACS-1460 was found most effective treatment. The plots with the genotypic mixtures of NRC-37, JS-9752, RSC-1046 and RKS-113 supported the least population of semiloopers. However, lowest population of leaf miner and girdle beetle was recorded in plots of JS-20-34 while the least population of stem fly was recorded in RSC-1046. The differences observed due to the genotypic combinations may be used for developing inset-pest management programmes in soybean.

Keywords: Sole variety, Soybean insect-pests, Varietal mixture

Cultivation of two or more different cultivars of a crop as a pest management tactic has been less commonly used in soybean [*Glycine max* (L.) Merr.] but mixing of two or more different cultivars of a crop were widely used in combinations like maize (*Zea mays* L.), sorghum (*Sorghum bicolor* L.), oats (*Avena sativa* L.) etc. (Cantelo and Sanford 1984, Martin *et al*. 1989, Holmes and Barrett 1997, Michaud *et al*. 2007, Shoffner and Tooker 2013, Parthiban *et al*. 2017, Sujyanand *et al*. 2021). Mixing multiple varieties with similar traits such as maturity duration alters the behaviour of insect-pests and natural enemies (Castro 2001, Cook *et al*. 2007). Continuous monoculture of single variety results in increased susceptibility to insect-pests attack as it enhances the pest adaptability and spread. Mixtures of susceptible and resistant varieties increase the intraspecific diversity and thus decrease the insect-pests population. It also increases the natural enemies population more due to the differential flowering duration.

The objective of this study was to determine the effects of varietal mixtures on the insect-pests population of soybean by comparing the population density between cultivation of single variety and mixture of varieties.

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MATERIALS AND METHODS

The experiment was conducted during rainy (*kharif*) seasons of 2018 and 2019 at the ICAR-Indian Institute of Soybean Research, Indore, Madhya Pradesh. All recommended agronomic practices were followed for cultivation of the crop. The experiment was laid out in a randomized block design (RBD) with three replication having plot size of 9 rows of 5 m length. The distance between rows, plots and replications was 0.45 m, 1 m and 1.5 m, respectively. To avoid the border effects, border rows were excluded for taking of observations. To assess the population of lepidopteran pests' and pod borer, the total number of larvae per meter rows was counted at three random spot in each plot. For stem fly observations per cent stem tunneling per plant was calculated. For this purpose, five plants randomly selected in each plot. Likewise, for girdle beetle observations 1-meter row length was selected at five spots in each plot and counted the total number and infested plants in each 1-meter row length. For statistical analysis all the row data were suitably transformed. For count data like defoliators and pod borer, square root transformation was used and for percent data like stem fly and girdle beetle, angular transformation was used. To manage the insect-pests of soybean by varietal mixtures, total 20 treatments were formed and evaluated for relative efficacy in management of insect-pests population of soybean and out of the 20 treatments, 4 treatments, viz. T_1 (mixture of JS-9560, JS-20-34, MAUS-47 and MACS-1460); T_6 (mixture of JS-9305, JS-2029, RVS-2001-4 and Dsb-28-3); T_{11} (mixture of NRC-86, JS-335, JS-2098 and RKS-45) and T_{16} (mixture of NRC-37, JS-9752, RSC-1046 and RKS-113) were the treatments of varietal mixture and rest of the treatments were of sole varietal treatments. Varietal mixtures treatments were made of 4 varietal mixtures of almost similar maturity duration and agronomic traits. For varietal mixture treatment, equal quantity of each variety seeds was taken and mixed well before sowing.

RESULTS AND DISCUSSION

Insect-pest population of soybean during kharif 2018: The population density of linseed caterpillar (*Spodoptera exigua*) in all the treatments ranged between 0.44–3.22 larva/m (Table 1). During *kharif* 2018, the population of linseed caterpillar (*Spodoptera exigua*) in treatment T_{16} (0.44) was statistically lowered significantly from all the treatments. The population density of tobacco caterpillar (*Spodoptera litura*) was ranged between 1.11–3.33 larva/m. The population of tobacco caterpillar in all varietal mixture treatments T_1 (1.56), T_6 (1.42), T_{11} (1.11) and T_{16} (1.60) was statistically lowered significantly from all other sole varietal treatments. The population density of semiloopers was ranged between 6.44–17.33 larva/m and was statistically lowered significantly in treatment T_{16} from all other treatments except T_2 (6.89) and T_6 (7.00). The population density of tussock moth was ranged between 0.1–1.3 and was at par with each other in treatment T_1 and T_{16} and statistically lowered significantly from all other treatments except T_6 (0.3) and T_{18} (0.3). The population density of grey weevil/meter was ranged between 0.11–1.0. The population density of blue beetle/meter was ranged between 0.1–1.2 and was statistically lowered significantly in varietal mixture treatments T_{16} (0.10) from their respective sole varietal treatments. The population density of leaf miner larva/m was ranged between 0.11–1.0 and was statistically lowered non-significantly in treatment T_1 (0.11) from its sole varietal treatments. In other treatments population density of leaf miner differed among all the treatments statistically non-significantly except T_{14} (1.00) and T_{18} (0.89) which had higher statistically significant population from other treatments. The per cent stem tunneling made by stem fly was ranged between 27.91–74.39% and differed statistically non-significantly among all the treatments except T_{14} (74.39) and T17 (57.9) where it was significantly higher from all other treatments. The per cent plant infestation by girdle beetle was ranged between 1.25–8.81%. The population density of girdle beetle was statistically lowered significantly in treatment T_3 (1.25) from T_1 (5.00), T_4 (7.05), T_5 (5.56), T_{10} (6.44), T_{15} (7.82), T_{19} (8.81) and T_{20} (6.63) treatments. The population density of pod borer was ranged between 0.7–2.1 larva/m and was statistically lowered significantly in all varietal mixture treatments from their respective sole varietal treatments except T_6 (1.9) wherein population of pod borer was found higher statistically significantly as compare to sole varietal treatments T_7 (1.4), T_8 (1.5) and T_9 (1.8). In T_{10} (2.1) (Table 1). The mean populations of all the insect-pests observed were in general low as compare to pooled mean population of all insect-pests (2018 and 2019). Similar kind of experiments were conducted in maize and it was found that in mixed stands of maize, densities of leafhoppers (*Dalbulus maidis* Delong and Wolcott) can be lower than those in pure stands (Power 1988, 1991). Similarly, mixing of susceptible and resistant varieties of potato reduced the populations of leafhoppers affecting crop (Cantelo and Sanford 1984). In a study on wheat aphid genotypic mixtures of two or more varieties reduced the growth rate and size of aphid (*Rhopalosiphum padi*) (Shoffner and Tooker 2013). The Mixing of different soybean cultivars provided more favourable climatic conditions i.e. comfortable temperature and relative humidity within plants which ultimately reduced the population of soybean pests (Peacock and Herrick 2000). In an experiment improved control of herbivorous insect populations was observed with genotypic diversity (Crutsinger *et al.* 2006). Increasing plant species diversity can also reduce the insect herbivores populations by increasing natural enemies populations (Haddad *et al*. 2009). In a recent study on barley, it was investigated that significantly lower aphid populations observed in varietal mixtures as compared to barley single varietal cultivation (Dahlin *et al*. 2018).

Insect-pest population of soybean during kharif 2019: The population density of linseed caterpillar (*Spodoptera exigua*) in all the treatments ranged between 1.22–2.78 larva/m (Table 2). The population density of tobacco caterpillar (*Spodoptera litura)* was ranged between 1.17–3.59 larva/m. The population density of semiloopers was ranged between 6.43–17.03 larva/m. The population density of tussock moth was ranged between 0.12–1.33. The population density of blue beetle/meter was ranged between 0.15–1.35. The population density of leaf miner larva/m was ranged between 0.29–1.11. The per cent stem tunneling made by stem fly larva in each treatment was ranged between 19.71–51.26%. The per cent plant infestation by girdle beetle was ranged between 4.92–13.86%. During *kharif* 2019, the population of linseed caterpillar (*Spodoptera exigua*) in varietal mixture treatment T_1 (1.33) and T_6 (1.44), T_{11} (1.22) and T_{16} (1.89) was statistically lowered significantly from all the treatments except, T_8 (1.44) and T_{17} and was at par with T_6 (1.44) and T_{16} (1.89), respectively. The population of tobacco caterpillar in all varietal mixture treatments, viz. T_1 (2.16), T_6 (1.90), T_{11} (1.17) and T_{16} (1.47) was statistically lowered significantly from all varietal treatments except T_2 (2.15) wherein, it was lowered statistically non-significantly. The population density of semiloopers in T_{16} treatment was statistically lowered significantly from all other treatments. The population density of tussock moth in T_1 (0.12) was statistically lowered significantly from all other treatments except T_{16} (0.20) and T_{17} (0.39), respectively in which it was statistically lowered but non-significantly from T_1. The population density of blue beetle in varietal mixture treatments T_{16} (0.10) was statistically lowered significantly from all other varietal treatments

Table 1 Insect-pest population of soybean during *kharif* 2018

Treatment	*S. exigua* larva/m	*S. litura* larva/m	Semi-loopers larva/m	Tussock moth larva/m	Grey weevil/m	Blue beetle/m	Leaf miner larva/m	Stem fly (Per cent stem tunneling)	Girdle beetle (Per cent plant infestation)	Pod borer larva/m
T_1 (Mixture of JS-9560, JS-20-34, MAUS-47 and MACS-1460)	1.00	1.56	11.56	0.1	0.33	0.20	0.11	40.67	5.00	0.7
T_2 (JS-9560)	1.44	2.11	6.89	0.5	0.33	0.80	0.22	28.99	2.06	1.9
T_3 (JS-20-34)	3.22	2.33	17.33	0.7	0.22	0.90	0.18	43.12	1.25	1.1
T_4 (MAUS-47)	1.21	2.45	10.33	0.9	1.00	1.00	0.19	30.70	7.05	1.6
T_5 (MACS-1460)	1.67	2.78	10.78	1.0	0.22	0.30	0.17	34.70	5.56	1.5
T_6 (Mixture of JS-9305, JS-2029, RVS-2001-4 and Dsb-28-3)	1.12	1.42	7.00	0.3	0.44	0.70	0.22	46.74	3.85	1.9
T_7 (JS-9305)	1.89	2.56	15.44	1.3	0.56	0.60	0.18	41.92	4.54	1.4
T_8 (JS-2029)	1.22	3.33	12.67	0.6	0.89	0.70	0.33	42.54	4.43	1.5
T_9 (RVS-2001-4)	1.33	2.35	9.78	0.7	0.33	0.50	0.33	42.71	4.87	1.8
T_{10} (Dsb-28-3)	1.89	2.11	8.78	0.9	0.56	1.10	0.16	36.56	6.44	2.1
T_{11} (Mixture of NRC-86, JS-335, JS-2098 and RKS-45)	1.11	1.11	8.00	0.3	0.11	0.40	0.33	49.12	3.66	1.1
T_{12} (NRC-86)	1.44	2.00	10.33	1.0	0.22	1.00	0.33	45.57	3.93	1.7
T_{13} (JS-335)	1.67	2.55	12.33	0.6	0.33	0.80	0.14	40.57	3.46	1.9
T_{14} (JS-2098)	1.56	2.89	7.56	0.4	0.44	0.60	1.00	74.39	2.58	2.0
T_{15} (RKS-45)	1.89	2.16	7.22	0.5	0.33	1.00	0.19	48.08	7.82	1.5
T_{16} (Mixture of NRC-37, JS-9752, RSC-1046 and RKS-113)	0.44	1.60	6.44	0.1	0.89	0.10	0.33	34.11	4.22	1.3
T_{17} (NRC-37)	1.56	2.10	12.35	0.4	0.78	1.10	0.44	57.91	2.18	2.0
T_{18} (JS-9752)	1.67	2.12	13.65	0.3	0.33	1.20	0.89	35.54	3.87	1.9
T_{19} (RSC-1046)	1.40	2.42	14.56	0.9	1.00	0.80	0.33	31.06	8.81	1.7
T_{20} (RKS-113)	1.67	1.98	15.60	0.6	0.33	0.70	0.17	27.91	6.63	1.6
SEm±	(0.36)	(0.14)	(0.33)	(0.13)	(0.23)	(0.12)	(0.19)	(4.73)	(1.70)	(0.09)
CD (P=0.05)	(0.73)	(0.27)	(0.66)	(0.27)	(0.47)	(0.23)	(0.39)	(9.58)	(3.45)	(0.19)
CV	(20.12)	(10.21)	(12.32)	(15.77)	(21.09)	(12.95)	(20.28)	(14.84)	(16.70)	(7.93)

except T_5 (0.30), T_{11} (0.43) and T_1 (0.26) in which it was statistically lowered but non-significantly as compare to T_{16}. The population density of leaf miner in T_1 (0.11) was statistically lowered non-significantly from its sole varietal treatments. In other treatments population density of leaf miner differed among all the treatments statistically non-significantly except T_{14} (1.11) and T_{18} (1.00) which had higher statistically significant population from other treatments. The per cent stem tunneling caused by stem fly was statistically lowered significantly from all the treatments except T_{19} (25.87) wherein it was non-significantly higher from T_1 treatment. The per cent girdle infestation of girdle beetle was statistically higher non-significantly in varietal mixture treatment T_1 (7.66) and T_6 (10.24) as compare to their respective sole varietal treatments. In T_{11} and T_{16} varietal mixture treatment per cent girdle infestation was statistically lowered non-significantly than their respective sole varietal treatments except T_{12} (7.02) and T_{18} (10.74). The population density of pod borer was statistically lower significantly in all varietal mixture treatments from their respective sole varietal treatments except T_6 (2.08) wherein it was found statistically higher but non-significantly as compare to sole varietal treatments T_7 (1.93), T_8 (1.93) and T_{10} (2.05). In T_9 treatment (2.13), population of pod borer was found statistically higher non-significantly as compare to its varietal mixture (Table 2). In a related experiment, Nault *et al.* (1992) reported that the resistance of certain soybean genotype to defoliating pests was attenuated during the reproductive stage compared to the vegetative stage. Leafhopper population density was relatively low in soybean based varietal mixture treatment as compared to monoculture of single variety because herbivores more easily can find, stay and reproduce in monocultures of host plants than in polycultures (Boot 1973). A lesser egg laying was observed on varietal mixture of cabbage by cabbageworms because more preferred plant varieties were masked from ovipositing moths by less preferred varieties (Cantelo and Sanford 1984, Hamback, Agren and Ericson 2000).

Effects of genotypic diversity in soybean revealed that for *Spodoptera exigua* management T_1 (JS-9560, JS-20-34, MAUS-47 and MACS-1460), T_{11} (NRC-86, JS-335, JS-2098 and RKS-45) and T_{16} (NRC-37, JS-9752, RSC-1046 and RKS-113) (1.17 larva/m) were found most effective treatment and at par with each other. In case of *Spodoptera litura,* tussock moth, blue beetle and grey weevil management T_1 (JS-9560, JS-20-34, MAUS-47 and MACS-1460) was found most effective treatment. For semiloopers treatment T_{16} (NRC-37, JS-9752, RSC-1046 and RKS-113) was found most effective. But for leaf miner and girdle beetle management T_3 (JS-20-34) was found most effective treatment. For stem fly management T_{19} (RSC-1046) was found most effective treatment. So, genotypic diverse treatments were found more effective than their respective sole varietal treatments for all defoliators except leaf miner, girdle beetle and stem fly management. Hence the results revealed that decreasing trends of insect-pests have been found in genotypic diverse treatments as compare to monocropping of single variety (Risch 1981, Letourneau 1987, Orlob 1961, Peacock and Herrick 2000). Lesser population of insect-pests was found in varietal mixture treatments as compared with their respective sole varietal treatments. The reasons behind this were that in diverse cultivar mixtures each variety has a different level of resistance against different insects (Nault *et al.* 1992,

Table 2 Insect-pest population of soybean during *kharif* 2019

Treatment	*S. exigua*/m	*S. litura*/m	Semi-loopers/m	Tussock moth/m	Grey weevil/m	Blue beetle/m	Leaf miner/m	Stem fly (Per cent tunneling)	Girdle beetle (Per cent infestation)	Pod borer larva/m
T_1 (Mixture of JS-9560, JS-20-34, MAUS-47 and MACS-1460)	1.33	2.16	11.09 (3.40)	0.12 (0.79)	0.42	0.26	0.44	19.71	7.66	1.37
T_2 (JS-9560)	1.78	2.15	7.67	0.84	0.36	0.76	0.33	38.70	6.03	2.23
T_3 (JS-20-34)	2.78	2.55	17.03	0.57	0.39	1.00	0.29	39.36	4.92	1.97
T_4 (MAUS-47)	1.39	2.77	9.97	1.22	0.44	1.28	0.36	35.83	10.17	2.00
T_5 (MACS-1460)	1.78	2.46	10.51	1.05	0.78	0.30	0.47	30.19	7.15	2.14
T_6 (Mixture of JS-9305, JS-2029, RVS-2001-4 and Dsb-28-3)	1.44	1.90	7.16	0.53	0.47	0.83	0.33	42.46	10.24	2.08
T_7 (JS-9305)	2.00	2.65	14.77	1.32	0.50	0.93	0.40	30.52	6.26	1.93
T_8 (JS-2029)	1.44	3.40	12.38	0.80	0.79	0.90	0.44	45.97	7.00	1.93
T_9 (RVS-2001-4)	1.89	2.37	12.12	1.18	0.36	0.58	0.47	34.63	6.65	2.13
T_{10} (Dsb-28-3)	2.11	2.23	9.75	1.30	0.78	1.19	0.38	39.49	10.05	2.05
T_{11} (Mixture of NRC-86, JS-335, JS-2098 and RKS-45)	1.22	1.17	8.63	0.60	0.33	0.43	0.40	38.32	7.26	1.38
T_{12} (NRC-86)	1.78	2.70	10.13	1.33	0.33	1.03	0.44	50.20	7.02	1.93
T_{13} (JS-335)	2.00	2.23	15.00	0.63	0.44	0.81	0.40	30.82	12.26	1.99
T_{14} (JS-2098)	1.89	3.59	9.89	0.67	0.50	0.70	1.11	51.26	9.69	2.16
T_{15} (RKS-45)	2.11	2.52	7.50	0.60	0.44	1.20	0.43	33.52	10.54	1.80
T_{16} (Mixture of NRC-37, JS-9752, RSC-1046 and RKS-113)	1.89	1.47	6.43	0.20	0.79	0.15	0.47	33.08	11.16	1.76
T_{17} (NRC-37)	1.89	2.27	12.21	0.39	0.78	1.35	0.53	33.89	11.51	2.28
T_{18} (JS-9752)	1.78	2.23	15.35	0.60	1.11	1.23	1.00	27.53	10.74	2.45
T_{19} (RSC-1046)	1.67	2.87	14.89	1.27	1.44	0.94	0.47	25.87	13.86	2.16
T_{20} (RKS-113)	1.89	2.23	15.78	0.86	0.67	0.67	0.40	32.20	12.41	1.85
SEm±	(0.16)	(0.17)	(0.35)	(0.19)	(0.31)	(0.14)	(0.30)	(3.46)	(3.25)	(0.15)
CD (P=0.05)	(0.32)	(0.35)	(0.71)	(0.37)	(0.63)	(0.28)	(0.60)	(7.00)	(6.57)	(0.30)
CV	(20.12)	(12.63)	(12.62)	20.31)	(25.83)		(27.00)	(11.78)	(23.12)	(11.78)

Costa *et al*. 2014). A comparable effect was found for eggs of imported cabbageworms on cabbage, perhaps because more preferred plant varieties were masked from ovipositing moths by less preferred varieties (Cantelo and Sanford 1984, Hamback, Agren and Ericson 2000). So, varietal mixture provides unsuitable environment for pest multiplication of herbivores. Also, diverse varietal mixture provides suitable climate for multiplication of natural enemies. There had been 56% more abundance and 80% more diversity of parasitoids in genotypic diverse mixture than monocropping of single variety (Jones *et al*. 2011). Genotypic diverse mixture resulted in lesser yellow mosiac virus (YMV) disease than monotypic stand which is transmitted by whitefly due increase movement, decrease acquition and transmission period of persistent virus like yellow mosiac virus because it requires longer period of whitefly feeding to transmit the virus to new host plant (Kennedy and Kishaba 1977, Power 1988, 1991). Herbivores induce direct defenses that interfere with herbivore feeding, growth fecundity and fertility (Walling 2000).

In conclusion, we can say that varietal cafeteria approach means growing of two or more varieties of early, medium and late duration certainly give results in changing climate scenario because some year we get drought and another year we get excessive rains and also distribution of rainfall is not uniform. So, this approach could be well fitted in such conditions. Every year we are getting different pests and it is happening more rapidly nowdays due to rapid climate change. So, it is very difficult to control these pests and also farmers are almost totally dependent on pesticides for their control which could create several problems such as insecticide resistance in insect-pests, pesticides residual in food due to excessive use of pesticides, pest resurgence, new pest emerging and environmental pollution. So, these approaches are non-chemical approach for soybean insect-pest management. Besides, it also provides a very good environment for natural and biological control by predators, parasitoids and entomopathogens.

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