

Genotypic mixture's effects on the population of soybean (*Glycine max*) pests

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ABSTRACT

In order to investigate the effects of genotypic mixing on the population of soybean [*Glycine max* (L.) Merr.] pests, an experiment was carried out at the ICAR-Indian Institute of Soybean Research in Indore and Madhya Pradesh during the rainy (kharif) seasons of 2018 and 2019. The relative effectiveness of 16 soybean genotypes and 4 genotypic mixes in controlling soybean insect pests was assessed. Plots with genotypic combinations had the lowest population of *Spodoptera exigua* Hubner among the 20 treatments, and they were comparable to one another. A combination of the genotypes JS-9560, JS-20-34, MAUS-47, and MACS-1460 was determined to be the most effective therapy for managing *Spodoptera litura* Fabricius, tussock moth, blue beetle, and gray weevil. Plots including genotypic mixes of RSC-1046, RKS-113, JS-9752, and NRC-37 supported the fewest semiloopers. However, plots of JS-20-34 had the lowest leaf miner and girdle beetle populations, whereas RSC-1046 had the lowest stem fly population. Programs for managing inset pests in soybeans may be developed using the variations found as a result of genotypic combinations.

Keywords: Varietal combination, soybean insect infestations, and sole variety

Introduction

Soybean [*Glycine max* (L.) Merr.] cultivation of two or more different crop cultivars has been less common as a pest management strategy; however, combinations of two or more different crop cultivars, such as maize (*Zea mays* L.), sorghum (*Sorghum bicolor* L.), oats (*Avena sativa* L.), etc., have been widely used (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). Insect pests and natural enemies behave differently when different types with comparable characteristics, including maturity time, are mixed together (Castro 2001, Cook et al. 2007). Continuous monoculture of a single type increases the pest's adaptability and proliferation, making it more vulnerable to insect-pest attacks. Combinations of sensitive and resistant types reduce the population of insect pests by increasing intraspecific variability. Because of the varying blossoming length, it also increases the number of natural enemies.

This research compared the population density between cultivation of a single variety and a combination of varieties in order to ascertain the impact of varietal mixes on the population of insect pests in soybeans.

IICAR, the Indian Institute of Soybean Research, is located in Indore, Madhya Pradesh. *The author's email address is lokesharsnagpur@gmail.com. MATERIALS AND METHODS

The experiment was carried out at the ICAR-Indian Institute of Soybean Research in Indore, Madhya Pradesh, during the rainy (kharif) seasons of 2018 and 2019. The crop was cultivated using all advised agronomic techniques. The experiment was set up using a randomized block design (RBD) with three replications and a plot size of nine rows each measuring five meters. Rows, plots, and replications were separated by 0.45 m, 1 m, and 1.5 m, respectively. Border rows were not included in the observation process to prevent border effects. The total number of larvae per meter row was counted at three random locations in each plot to determine the population of pod borer and lepidopteran pests. The percentage of stem tunneling per plant was computed using stem fly observations. Five plants were chosen at random from each plot for this purpose. Similarly, a 1-meter row length was chosen at five locations in each plot for girdle beetle observations, and the total number of infected plants in each row length was tallied. All of the row data were appropriately converted for statistical analysis. Square root transformation was used for count data, such as defoliators and pod borer, while angular transformation was used for percentage data, such as stem fly and girdle beetle. In order to control soybean insect pests using varietal combinations, a total of twenty treatments were created and assessed for their relative

effectiveness in controlling the population of soybean insect pests. Of these, four treatments, namely T1 (mixing),

of JS-9560, JS-20-34, MAUS-47, and MACS-1460; T6 (mixture of JS-9305, JS-2029, RVS-2001-4, and Dsb-28-3); T11 (mixture of NRC-86, JS-335, JS-2098, and RKS-45); and T16 (mixture of NRC-37, JS-9752, RSC-1046, and RKS-113). Four varietal blends with almost identical maturation durations and agronomic characteristics were used in the varietal mixtures treatments. Before planting, an equal amount of each variety's seeds were obtained and thoroughly mixed for the varietal mixing treatment.

OUTCOMES AND TALK

Soybean insect-pest population during Kharif 2018: In every treatment, the linseed caterpillar (*Spodoptera exigua*) population density varied from 0.44 to 3.22 larva/m (Table 1). The linseed caterpillar (*Spodoptera exigua*) population in treatment T16 (0.44) during kharif 2018 was statistically considerably lower than that of all the treatments. The tobacco caterpillar (*Spodoptera litura*) population density varied from 1.11 to 3.33 larva/m. In comparison to the other solo varietal treatments, the population of tobacco caterpillars in varietal mixing treatments T1 (1.56), T6 (1.42), T11 (1.11), and T16 (1.60) was statistically considerably reduced. With the exception of T2 (6.89) and T6 (7.00), treatment T16 dramatically reduced the population density of semiloopers, which varied from 6.44 to 17.33 larva/m. Tussock moth population densities varied from 0.1 to 1.3, were comparable in treatments T1 and T16, and were statistically considerably lower in all other treatments with the exception of T6 (0.3) and T18 (0.3). Gray weevil population densities per meter varied from 0.11 to 1.0. The varietal mixing treatments T16 (0.10) had a much lower population density of blue beetles per meter than the corresponding solo varietal treatments, with a range of 0.1–1.2. Treatment T1 (0.11) had a statistically non-significantly lower population density of leaf miner larvae/m than its mono varietal treatments, with a range of 0.11–1.0. With the exception of T14 (1.00) and T18 (0.89), which had greater statistically significant populations than the other treatments, the population density of leaf miners varied statistically non-significantly across all treatments. With the exception of T14 (74.39) and T17 (57.9), where it was substantially greater than all other treatments, the percentage of stem tunneling produced by stem flies ranged from 27.91 to 74.39% and varied statistically non-significantly across all treatments. The percentage of plants infested with girdle beetles varied from 1.25 to 8.81%. Girdle beetle population density was statistically substantially reduced in treatment T3 (1.25) compared to treatments T1 (5.00), T4 (7.05), T5 (5.56), T10 (6.44), T15 (7.82), T19 (8.81), and T20 (6.63).

The pod borer population density ranged from 0.7 to 2.1 larva/m and was statistically significantly lower in all varietal mixture treatments compared to their corresponding sole varietal treatments, with the exception of T6 (1.9), where the population was found to be statistically significantly higher in comparison to sole varietal treatments T7 (1.4), T8 (1.5), and

T9 (1.8). T10 (2.1) (Table 1). In comparison to the pooled mean population of all insect pests (2018 and 2019), the mean populations of all insect pests detected were generally low. Similar studies were carried out on maize, and it was discovered that leafhopper densities (*Dalbulus maidis* DeLong and Wolcott) in mixed stands of maize might be lower than those in pure stands (Power 1988, 1991). In a similar vein, combining susceptible and resistant potato cultivars decreased the number of leafhoppers that damaged crops (Cantelo and Sanford 1984). In a research on wheat aphids, genotypic combinations of two or more kinds decreased the aphids' (*Rhopalosiphum padi*) size and growth rate (Shoffner and Tooker 2013). The number of soybean pests was eventually decreased by the mixing of several soybean cultivars, which produced more favorable climatic circumstances, such as agreeable temperatures and relative humidity inside plants (Peacock and Herrick 2000). Genotypic variety was shown to assist the management of herbivorous insect populations in an experiment (Crutsinger et al. 2006). By boosting the numbers of natural enemies, diversifying plant species may also lower the populations of insect herbivores (Haddad et al. 2009). Aphid populations were found to be much lower in varietal combinations than in barley single varietal farming, according to a recent research on barley (Dahlin et al. 2018).

Soybean insect-pest population in Kharif 2019: The linseed caterpillar (*Spodoptera exigua*) population density varied from 1.22 to 2.78 larva/m across all treatments (Table 2). The tobacco caterpillar (*Spodoptera litura*) population density varied from 1.17 to 3.59 larvae/m. The semilooper population density varied from 6.43 to 17.03 larvae/m. The tussock moth population density varied from 0.12 to 1.33. The blue beetle population density per meter varied from 0.15 to 1.35. The range of the leaf miner larvae population density/m was 0.29–1.11. In each treatment, the percentage of stem tunneling by stem fly larvae varied from 19.71 to 51.26%. The

percentage of plants infested with girdle beetles varied from 4.92 to 13.86%. With the exception of T8 (1.44) and T17, the population of linseed caterpillars (*Spodoptera exigua*) in varietal mixture treatments T1 (1.33), T6 (1.44), T11 (1.22), and T16 (1.89) was statistically significantly reduced during kharif 2019 and was comparable to T6 (1.44) and T16 (1.89), respectively. With the exception of T2 (2.15), which had a statistically non-significant decrease, the tobacco caterpillar population in all varietal mixing treatments—T1 (2.16), T6 (1.90), T11 (1.17), and T16 (1.47)—was statistically considerably reduced. Compared to all other treatments, the population density of semiloopers in the T16 therapy was statistically considerably lower. With the exception of T16 (0.20) and T17 (0.39), where it was statistically dropped but not considerably from T1, the tussock moth population density in T1 (0.12) was statistically lowered significantly from all other treatments. Compared to all other varietal treatments, the blue beetle population density in varietal combination treatments T16 (0.10) was statistically considerably lower.

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 tunneling)	Girdle beetle (Per cent plant infestation)	Pod borer larva/m
T1 (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
T2 (JS-9560)	1.44	2.11	6.89	0.5	0.33	0.80	0.22	28.99	2.06	1.9
T3 (JS-20-34)	3.22	2.33	17.33	0.7	0.22	0.90	0.18	43.12	1.25	1.1
T4 (MAUS-47)	1.21	2.45	10.33	0.9	1.00	1.00	0.19	30.70	7.05	1.6
T5 (MACS-1460)	1.67	2.78	10.78	1.0	0.22	0.30	0.17	34.70	5.56	1.5
T6 (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
T7 (JS-9305)	1.89	2.56	15.44	1.3	0.56	0.60	0.18	41.92	4.54	1.4
T8 (JS-2029)	1.22	3.33	12.67	0.6	0.89	0.70	0.33	42.54	4.43	1.5
T9 (RVS-2001-4)	1.33	2.35	9.78	0.7	0.33	0.50	0.33	42.71	4.87	1.8
T10 (Dsb-28-3)	1.89	2.11	8.78	0.9	0.56	1.10	0.16	36.56	6.44	2.1
T11 (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
T12 (NRC-86)	1.44	2.00	10.33	1.0	0.22	1.00	0.33	45.57	3.93	1.7
T13 (JS-335)	1.67	2.55	12.33	0.6	0.33	0.80	0.14	40.57	3.46	1.9
T14 (JS-2098)	1.56	2.89	7.56	0.4	0.44	0.60	1.00	74.39	2.58	2.0
T15 (RKS-45)	1.89	2.16	7.22	0.5	0.33	1.00	0.19	48.08	7.82	1.5
T16 (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
T17 (NRC-37)	1.56	2.10	12.35	0.4	0.78	1.10	0.44	57.91	2.18	2.0
T18 (JS-9752)	1.67	2.12	13.65	0.3	0.33	1.20	0.89	35.54	3.87	1.9
T19 (RSC-1046)	1.40	2.42	14.56	0.9	1.00	0.80	0.33	31.06	8.81	1.7
T20 (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)

with the exception of T5 (0.30), T11 (0.43), and T1 (0.26), where it was statistically reduced but not statistically significant when compared to T16. The leaf miner population density in T1 (0.11) was statistically reduced from its single varietal treatments in a non-significant way. With the exception of T14 (1.11) and T18 (1.00), which had greater statistically significant populations than the other treatments, the population density of leaf miners varied statistically non-significantly across all treatments. With the exception of T19 (25.87), when it was non-significantly greater from the T1 treatment, the percentage of stem tunneling produced by stem flies was statistically considerably reduced from all treatments. In comparison to their respective solo varietal treatments, the percentage of girdle beetle infestation in varietal mixing treatments T1 (7.66) and T6 (10.24) was statistically greater but not statistically significant. With the exception of T12 (7.02) and T18 (10.74), the percentage of girdle infestation in T11 and T16 varietal mixing treatments was statistically reduced non-significantly compared to their corresponding solo varietal treatments. With the exception of T6 (2.08), which was found to be statistically higher but not statistically significant when compared to sole varietal treatments T7 (1.93), T8 (1.93), and T10 (2.05), the population density of pod borer was statistically lower in all varietal mixture treatments from their respective sole varietal treatments. In comparison to its varietal combination, the pod borer population in the T9 treatment (2.13) was found to be statistically greater but not statistically significant (Table 2). In a comparable experiment, Nault et al. (1992) found that certain genotypes of soybeans had less resilience to defoliating pests during the reproductive stage than during the vegetative stage. Because herbivores may more readily locate, remain, and procreate in host plant monocultures than in polycultures, leafhopper population density was comparatively lower in the soybean-based varietal mixing treatment than in the single variety monoculture (Boot 1973). Because less favored plant types concealed more preferred plant varieties from ovipositing moths, less eggs were laid by cabbageworms on varietal mixtures of cabbage (Cantelo and Sanford 1984, Hamback, Agren and Ericson 2000).

T1 (JS-9560, JS-20-34, MAUS-47, and MACS-1460), T11 (NRC-86, JS-335, JS-2098, and RKS-45), and T16 (NRC-37, JS-9752, RSC-1046, and RKS-113) (1.17 larva/m) were found to be the most effective treatments for managing *Spodoptera exigua*. The most successful therapy for *Spodoptera litura*, tussock moth, blue beetle, and gray weevil management was T1 (JS-9560, JS-20-34, MAUS-47, and MACS-1460). The most successful therapy for semiloopers was T16 (NRC-37, JS-9752, RSC-1046, and RKS-113). However, T3 (JS-20-34) was determined to be the most successful therapy for managing girdle beetles and leaf miners. The most successful medication for stem fly control was discovered to be T19 (RSC-1046). Therefore, for all defoliators except leaf miner, girdle beetle, and stem fly management, genotypic varied treatments were shown to be more successful than their respective solitary varietal treatments. As a consequence, the findings showed that, in contrast to monocropping a single variety, genotypic varied treatments showed declining trends of insect pests (Risch 1981, Letourneau 1987, Orlob 1961, Peacock and Herrick 2000). Insect pest populations were lower in varietal combination treatments than in the corresponding solitary varietal treatments. This was due to the fact that each variety in a range of cultivar combinations had varying degrees of insect resistance (Nault et al. 1992,

Table 2 Insect-pest population of soybean during kharif 2019

Treatment	S. exigua/ m	S. litura/m	Semi- loopers/ m	Tussoc k moth/m m	Grey weevil/ m m	Blue beetle/m	Leaf miner/m	Stem fly (Per cent tunneling)	Girdle beetle (Per cent infestation n)	Pod borer larva/ m
T1 (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
T2 (JS-9560)	1.78	2.15	7.67	0.84	0.36	0.76	0.33	38.70	6.03	2.23
T3 (JS-20-34)	2.78	2.55	17.03	0.57	0.39	1.00	0.29	39.36	4.92	1.97

T4 (MAUS-47)	1.39	2.77	9.97	1.22	0.44	1.28	0.36	35.83	10.17	2.00
T5 (MACS-1460)	1.78	2.46	10.51	1.05	0.78	0.30	0.47	30.19	7.15	2.14
T6 (Mixture of JS-1.44 9305, JS-2029, RVS- 2001-4 and Dsb-28-3)	1.90	7.16	0.53	0.47	0.83	0.33	42.46	10.24	2.08	
T7 (JS-9305)	2.00	2.65	14.77	1.32	0.50	0.93	0.40	30.52	6.26	1.93
T8 (JS-2029)	1.44	3.40	12.38	0.80	0.79	0.90	0.44	45.97	7.00	1.93
T9 (RVS-2001-4)	1.89	2.37	12.12	1.18	0.36	0.58	0.47	34.63	6.65	2.13
T10 (Dsb-28-3)	2.11	2.23	9.75	1.30	0.78	1.19	0.38	39.49	10.05	2.05
T11 (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
T12 (NRC-86)	1.78	2.70	10.13	1.33	0.33	1.03	0.44	50.20	7.02	1.93
T13 (JS-335)	2.00	2.23	15.00	0.63	0.44	0.81	0.40	30.82	12.26	1.99
T14 (JS-2098)	1.89	3.59	9.89	0.67	0.50	0.70	1.11	51.26	9.69	2.16
T15 (RKS-45)	2.11	2.52	7.50	0.60	0.44	1.20	0.43	33.52	10.54	1.80
T16 (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
T17 (NRC-37)	1.89	2.27	12.21	0.39	0.78	1.35	0.53	33.89	11.51	2.28
T18 (JS-9752)	1.78	2.23	15.35	0.60	1.11	1.23	1.00	27.53	10.74	2.45
T19 (RSC-1046)	1.67	2.87	14.89	1.27	1.44	0.94	0.47	25.87	13.86	2.16
T20 (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 and associates (2014). Eggs of imported cabbageworms were shown to have a similar impact on cabbage, perhaps because less favored plant types concealed more preferred plant varieties from moths that lay eggs (Cantelo and Sanford 1984, Hamback, Agren and Ericson 2000). Therefore, a variety combination creates an inappropriate habitat for herbivore pest proliferation. Additionally, a varied variety mix creates an environment that is conducive to the growth of natural enemies. Compared to monocropping a single variety, the genotypic varied combination showed 56% more parasitoid abundance and 80% greater diversity (Jones et al. 2011). Yellow mosaic virus (YMV) disease was less common in genotypically diverse mixtures than in monotypic stands, which are spread by whiteflies. This is because persistent viruses like YMV require longer periods of time for whiteflies to feed in order to spread to new host plants (Kennedy and Kishaba 1977, Power 1988, 1991). Direct defenses that hinder herbivore eating, development, fecundity, and fertility are induced by herbivores (Walling 2000).

In conclusion, we can say that the varietal cafeteria approach, which involves growing two or more varieties of early, medium, and late duration, will undoubtedly result in a changing climate scenario because the distribution of rainfall is not uniform and we may experience drought in one year and excessive rains in another. Therefore, this strategy could work effectively in certain circumstances. We acquire new pests every year, and because of the quick changes in the environment, this is occurring more quickly these days. Therefore, controlling these pests is extremely challenging, and farmers rely almost entirely on pesticides to do so. This could lead to a number of issues, including insecticide resistance in insect pests, pesticide residue in food from overuse, pest resurgence, the emergence of new pests, and environmental pollution. Therefore, these methods for controlling insect pests in soybeans are non-chemical. Additionally, it offers an excellent setting for biological and natural control by parasitoids, entomopathogens, and predators.

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