Influence of Genotype on the Expression of Host Plant Resistance in Soybean (Glycine Max (L.) Mirrill) to the Major Insect Pests of Soybean in Umudike

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Abstract: Due to low annual production output of soybean grains in Nigeria which was attributed to insect pests infestation, six soybean genotypes were screened for major insect pests resistance in the National Root Crops Research Institute (NRCRI), Umudike. The trials were arranged in the Randomized Complete Block Design with four replicates during 2014 and 2015 growing seasons under the tropical climatic conditions. Analyses were done by pooling over two years due to insignificant genotype X year interactions. Rank summation index (RSI) results showed that TG X 1448 (V6) with RSI value of 17 had overall best performance in terms of resistance, yield and other yield related attributes. Result obtained from correlation indicated that grain yield was significantly and positively correlated with pod number per plant (r = 0.907*) and seed number per pod (r = 0.691*). Conversely, significant and negative correlation was recorded between grain yield and number of damage pod per plant (r = -0.616*). Compared to the simple correlation analysis, path analysis of grain yield and its traits demonstrated that pod number per plant and pod length evolved the highest positive direct influence, 1.80 and 0.65 respectively. Hence, selection for these traits could bring improvement in yield and yield components.

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1. Introduction

Soybean (Glycine max (L.) Merrill), a *legume* has been grown for three millennia in Asia and recently, has been successfully cultivated around the world. Today, the world's top producers of soybean are the United States, Brazil, Argentina, China and India (ASA, 2012). Soybean is one of the few plants that provide a complete protein as it contains all eight amino acids essential for human health. It is the world's most important source of vegetable oil that is a rich source of vitamin E in human nutrition (Giller and Dashiell, 2007).

Soybean has an average protein content of 40% and is more protein-rich than any of the common vegetable sources. Soybean seeds also contain about 20% oil on a dry matter basis, and this is 85% unsaturated and cholesterol-free (Dugje *et al*., 2009).

Soybean therefore, serves as a cheap source of protein in meeting human dietary requirement in poor countries of the World, such as Nigeria. Soybean is widely cultivated in the tropical, subtropical and temperate regions of the world (Giller and Dashiell, 2007). The crop can be successfully grown in many states in Nigeria using low agricultural input. Soybean cultivation in Nigeria has expanded as a result of its nutritive and economic importance and diverse domestic usage.

Despite global effort to increase soybean production, Nigeria has a very low annual production of 439,000t/ha, accounting for only 0.25% of the world annual output of 173 million tons between 1999 and 2003 (FAO, 2005). This low annual production output of soybean grains in Nigeria could be attributed to pests infestation (Tefera, 2011), as crop production is generally difficult in the tropics because of the favourable conditions which promote pest development (Orawu *et al*., 2001).

The Aphids, Aphis glycines (Matsumura) (Hemiptera: Aphididae), Soybean Looper, Chrysodeixincludens (Walker) (Lepidoptera: Noctuidae), Bean leaf beetle, Cerotoma trifurcate (Förster) (Coleoptera: Chrysomelidae), and Green stink bug (Acrosternumhilare) and Brown stink bug (Euchistusservus) are pests of major economic importance during its three growth stages (seedling, flowering and fruiting).

According to Ragsdale *et al*. (2007), these insects have the ability to reduce plant height, pod set, seed size and the amount of protein in seeds and have been known to reduce yields by as much as 40%. Aphids are the first insect pest in the United States capable of wide-spread damage in soybeans (Ragsdale *et al*., 2004). For averting losses due to these pests, whole reliance has been on pesticides as a tool of pest control and foreign exchange worth millions of dollars is being spent every year (Anonymous, 2001).The continuous and indiscriminate use of large quantities of synthetic insecticides, besides creating health hazards to human and animal life, as well as environmental pollution, has also resulted in the crop failure in different parts of the world, outbreak of secondary pests and development of resistance to insecticides in large number of insects (Rahman et al., 2006; Raju et al., 2007; Naik et al., 2008; Ghosh and Senapati, 2009).

In view of existing situation and importance of soybean for Nigeria, it is necessary to explore control measures such as host plant resistance (HPR) that is safe, cheap, easy to adopt and effective. HPR results from genetically-based changes in the morphology (leaf shape, stature and hairiness), chemistry (levels of toxins, growth retardants) or phenology (influence of climate on annual phenomena such as flowering) of the plant. HPR is often targeted at specific pests and provides a crop variety with a level of in-built protection against the pest. According to Snelling (1941), resistance includes those characteristics which enable a plant to avoid, tolerate, or recover from the attacks of insects under conditions that would cause greater injury to other plants of the same species.

There are three categories of HPR: antibiosis, anti xenosis, and tolerance. Antibiosis occurs when feeding on a host plant has a negative impact on the survival and egg production, development, feeding, oviposition, egg hatching, orientation, or fecundity of the herbivore, or any combination of the three. Antixenosis, or 'non preference', occurs when the herbivore determines the host-plant is an unsuitable food source and feeds very little, if at all. Tolerance is distinct from antibiosis and anti xenosis; as opposed to being defined by its effect on a herbivore, tolerance is defined as an increased threshold of a host plant to not experience an economic loss during infestation when compared to a susceptible plant (Painter, 1951; Panda and Khush, 1995; Koegan and Ortman, 1978). Research into sources of HPR in soybeans has primarily focused on the mechanisms of antibiosis and anti xenosis. Some of the biochemical and morphological factors affecting plant resistance are presence of; gossypol, phenolic compound, DIMBOA, oryzanone in plants (Glenn *et al.*, 1971), while temperature, light, relative humidity, soil fertility are known environmental factors that affect the ability of plants to resist pest attacks (Painter, 1951).

Host-plant resistance can be a valuable tool for the management of the soybean aphid. The mechanisms of resistance will allow growers to produce soybeans while using fewer chemical management strategies; this, in turn, will save on expenses as well as preserve communities of natural enemies. Owing to lack of information, the present study has been initiated not only to study an overall population situation of chewing and biting insect pests of soybean in Umudike but also to discover sources of host-plant resistance within the soybean germplasm.

2. Materials and Methods:

The experiment on the influence of genotype on the expression of host plant resistance in soybean was conducted in 2014 and 2015 planting seasons at the National Root Crops Research Institute (NRCRI), Umudike situated at Latitude $05^{0}28'$ N, Longitude $06^{0}52'$E and Altitude 122m above sea level in 2015 cropping season. Umudike has a total rainfall of about 2000-2500mm per annum with annual average temperature of about 260C.

The predominant vegetative type is rain forest (NEST, 1991). However, the soil was classified as sandy loam ultisol. The soybean genotypes were obtained from National Cereals Research Institute, Badegi, Nigeria (Table 1). The seeds were planted at 2 seeds per hill with spacing of 75 × 5cm in a plot area of 2 × 1m. Which gave plant population density of 533,332 plants/ha. The experiments were laid out in a Randomized Complete Block Design with four replications. Weeding was done regularly and manually to reduce inter-species competition.

Table 1: *Six genotypes of soybean evaluated*

Genotypic code	Name of genotype
V1	TG x 923 – ZE
V2	TG x 579
V3	TG x 1014 – ZED
V4	TG x 1019 – ZED
V5	TG x 360 – OZD
V6	TG x 1448

Pest scouting frequency.

Aphis craccivora: This was observed weekly on 20 randomly selected soybean stands in the 2 middle rows of each plot. Each was counted and mean calculated. Four observations were made beginning from 2WAP between 8.00 a.m. and 10.00 a.m. A hand lens and diagnostic manual for the identification of insect pathogens published by Poinar and Thomas (1978) was used for confirmation of insect identity.

Table 2: *Average Rainfall and Temperature pattern of the environment between May and August 2014 and 2015.*

Month	Rainfall (cm)		Temperature (0C)	
	Amount	Days	Max	Min
May	246.8	15	32.6	23.4
June	371.1	21	29.8	23.5
July	131.9	19	27.3	24.4
August	363.7	23	27.3	23.2

Pod damage: Pod damage were determined in the field at maturity by visual rating on a scale of 1- 9 (Jackai and Singh, 1988) from the 2 central rows of each plot. Holes and presence of frass on pods and sticking of pods were used as pod damage index.

2. Data Analyses:

The data for the two years were pooled as there were no significant differences between years. Agronomic and insect pests damage parameters collected were subjected to uni- and multi-variate analyses to select promising genotypes. The procedures used include; Pearson Correlation Coefficient used to estimate the relationships between the yield and yield related traits Ofori (1996), while Path analysis was used to Quantify the contribution of causal variables to a targeted effect variable directly and indirectly through other variables (Akinnola, 2012).

A Rank Summation Index (RSI) method was introduced to rank the genotypes for their overall performance as proposed by Ngwuta (2007). To obtain the RSI, genotypes were first ranked for each parameter (that is; 1= best genotype and 6 = poorest genotype) and the parameter ranks summed to generate overall performance of each genotype. Data for insect observation yield and yield related components were subjected to analysis of variance (ANOVA) which was used to compare variables using GenStat (2012) and Statistical Package for Social Sciences (SPSS). Amos SPSS was used for path coefficient analysis while significant means were separated by Fisher's Least Significant Difference Test (LSD), at 5% level of significance.

3. Results and Discussion:

The highly significant differences in variety observed for grain yield and all the other traits is an indication that the studied population is genetically diverse for all the traits studied. This observation is consistent with the findings of Aduloju *et al*. (2009). From Table 3, TG X 1019 – ZED (V4) was observed to be the tallest genotypes (39.23cm), while TG X 1448 (V6) was the shortest (28. 97cm) genotype.

This variation in heights could be attributed to genotypic differences among the genotypes. The number of leaf beetle and Aphid increased from 6 WAP to 9WAP and decreased at 12 WAP. The decrease in the population could probably be ascribed to weather factors which could have possibly hindered their migratory activity as rains were heavy and frequent at that period. The decreased number of leaf beetle and Aphid as indicated in this study agree with the findings of Degri and Hadi (2000) who reported from Bauchi, the absence of Aphid on field cowpea under heavy rain fed condition.

Perhaps, leaf beetle and Aphid would prefer a warm weather mixed with rains as encountered in the early cropping season in the area. The least number of; Leaf beetle, Soybean looper and Aphid per plant recorded on TG X 1014-ZED (V3) and TG X 1019 – ZED (V4) at different weeks under study showed that resistant genotypes harboured the least numbers. However, TG X 360 - OZD (V5) genotype exhibited moderate resistant, while TG X 923-ZE (V1), TG X 579 (V2) and TG X 1448 (V6) appeared as susceptible ones. These variations in genotypes susceptibility to infestation caused by these insect pests may be due to the presence of anti-xenosis (non-preference) and/or antibiosis phenomena, as described by Van Emdan (1987), who indicated that anti-xenotic plants can be avoided or less colonized by pests seeking food or oviposition site. However, he described Antibiosis as the position of some property by the plant, which directly or indirectly affects the performance of pests in term of survival, growth, development rate, fecundity, etc.

Onyishi *et al*. (2013) reported that genotypes, which recorded the least number of insect pests indicate that they possessed morphological and biochemical factors that made them less preferred by insect pests. The data of pod number per plant and pod length observed in Table 3, indicates that TG X 579 (V2) produced the highest number of pods per plant (30.20), followed by TG X 1448 (V6) (27.33) while TG X 360 - OZD (V5) produced the longest pod (11.30cm). This may be due to the genotypic variation among the soybean genotypes. The results corroborate the findings of Kelechukwu *et al*. (2007) who reported that the number of pods and pod length of cowpea is dependent on the type of variety as certain varieties are genetically more in number and longer than others.

The lowest number of damage pod (3.13) recorded in TG X 1014-ZED (V3) may be as a result of their resistance and chemical constitution which made them be avoided by these insects. This view is in agreement with Zaren (1987) who believed that the variation in cultivar susceptibility to pest infestation may be due to antibiosis, morphological and physiological character of plant and the number of glands and hairs. Again, this supported Harriman *et al.* (2014) that maintained that reasonable silicate deposits in leaves of some crops make them unattractive to leaf feeding insect pests since it slows down the rate of digestion of pests. The variations observed among the genotype in seed number per pod and grain yield could be attributed to their genetic dissimilarity.

This implied that seed number per pod and grain yield were genetically controlled. However, earlier studies conducted by several researchers revealed varietal differences in the grain yield of soybean (Sanginga et al., 2000; Nirmal et al., 2001) and this accounted for the varietal variations in yield in this study. The reliability of a parameter to be selected for breeding programme among other factors is dependent on the magnitude of its coefficient of variations (CV). It shows the extent of variability in relation to the mean of the population. While a lower value of CV generally depicts low variability among the tested sample; a high proportion CV indicates high variation. The CV recorded in all the parameters studied was low.

3.1. Rank Summation Index

The identification of the best genotypes supports the usefulness of selection index, in this case, rank summation index (RSI) for selection purpose was used (Ngwuta *et al*., 2007). To obtain the RSI, genotypes were first ranked for each parameter (that is 1 = best and 6 = poorest) and parameter ranks summed to generate overall performance of each genotype. Hence, the lower the RSI of any genotype, more desirable and the better is its agronomic performance. Therefore, the ranking of the 6 soybean genotypes (Table 5) for best performance using damage and yield attributes showed that genotype TG X 1448 (V6)had the best overall performance levels with a Rank Summation Index (RSI) value of 17. This was followed by TG X 1014-ZED (V3) that had the RSI value of 20.

3.2. Correlation:

Selection based on the detailed knowledge of magnitude and direction of association between yield and its attributes is very important in identifying the key characters, which can be exploited for crop improvement through suitable breeding programme. Correlation between yield and yield components were computed for soybean genotypes (Table 6). Stronger and positive correlations were found between grain yield and pod number per plant (r = 0.907*), seed number per plant (r = 0.691*) and pod length (r = 0.535).

These results showed that any positive increase in such characters will suffice the boast in grain yield. These findings were in similar with the results of Burhan (2007). It indicates that grain yield can be increased whenever there is an increase in characters that showed positive and significant association with grain yield. Hence, these characters can be considered as criteria for selection for higher yield as these were mutually and directly associated with yield. On the other hand, negative and significant correlations were determined between grain yield and number of damage pod per plant (r = -0.616*). These results were in unison with Kavita and Reddi (2001) and Reedy *et al.* (1997).

2.7. Path Coefficient Analysis

Grain yield, which is accepted as a major economic character in soybean and due to its complex nature depends on all other yield components. Change in anyone of the components could ultimately disturb the balance. In order to get a clear picture of the interrelationship between these traits, the direct and indirect effects of different characters were worked out using path coefficient analysis (figure 1.) in respect of the grain yield (Singh et al., 2004).

The Path coefficient analysis based on grain yield as a dependent variable revealed that pod number per plant and pod length evolved the highest positive direct influence, 1.80 and 0.65 respectively. Conversely, seed number per plant and number of damage pod per plant had a negative and low direct effect (-0.14 and -0.33 respectively) on grain yield. Besides, most of these traits exhibited indirect influence on grain yield. Thus, these traits could be used more confidently as the selection criteria in the grain yield improvement of soybean. Similar results in support of our results were given by other researchers (Oktem, 2008; Burhan, 2007).

4. Conclusion

Rank summation index (RSI) results identified TG X 1448 (V6) with RSI value of 17 as the overall best performer in terms of resistance, yield and other yield related attributes. While TG X 1019 – ZED (V4) with RSI value of 25 is the least performed genotype. Using path coefficient analysis for selection criteria, pod number per plant and pod length could be used as a selection criterion due to its highly positive direct effect on grain yield also indirect effects on all other characters.

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Appendix

Table 3: *Agronomic and damage traits variations of 6 soybean genotypes*

GENOTYPE	PH (cm)	NL	D50%F	NLB/P AT; 6WAP	NLB/P AT; 9WAP	NLB/P AT; 12WAP	NSL/P AT; 6WAP	NSL/P AT; 9WAP	NSL/P AT; 12WAP	NA/P AT 6WAP	NA/P AT 9WAP	NA/P AT 12WAP	NDL/P	PLD/P
TG X 923-ZE (V1)	32.43	49.7	60.00	2.900	3.033	2.333	1.600	1.033	1.833	1.967	3.067	1.900	10.67	21.63
TG X 579 (V2)	31.03	33.7	57.67	2.567	2.633	1.867	1.400	0.767	1.633	1.133	1.833	0.800	7.90	23.80
TG X 1014-ZED (V3)	33.50	40.7	58.67	2.400	2.967	2.233	2.567	2.000	2.767	2.600	3.733	2.167	12.33	30.97
TG X 1019 – ZED (V4)	39.23	44.3	53.67	3.300	3.800	2.967	3.200	2.300	3.433	2.900	4.300	2.400	15.23	34.37
TG X 360 - OZD (V5)	32.43	42.7	54.67	2.800	2.933	2.500	2.033	1.833	2.400	2.533	3.267	2.000	11.67	27.30
TG X 1448 (V6)	28.97	39.7	57.00	2.600	3.133	2.100	1.733	1.400	2.000	1.567	2.067	1.367	9.70	24.50
MEAN	32.93	41.8	56.94	2.761	3.083	2.333	2.089	1.556	2.344	2.117	3.044	1.772	11.25	27.09
LSD (0.05)	3.424	8.12	NS	NS	0.6517	0.6959	0.3782	0.2692	0.4131	0.3062	0.4844	0.3038	2.320	6.931
CV (%)	1.0	6.1	1.7	1.3	0.9	5.8	5.7	5.3	4.1	15.1	2.8	3.8	3.7	3.5

PH = Plant height (cm), NL = Number of leaves, D50%F = Days to 50% flowering, NLB/P = Number of leaf Beetle per plant, NSL/P = Number of soybean Looper per plant, NA/P = Number of Aphid per plant, NDL/P = Number of damaged leaf per plant, PLD/P = Percentage leaf damage per plant (%).

Table 4: *Genotypic variation of 6 soybean cultivars on the number of pods per plant, pod length, number of damaged pod per plant, percentage damaged pod per plant, seed number per pod and grain yield.*

GENOTYPE	POD NO. PER PLANT	POD LENGTH (CM)	NO. OF DAMAGED POD PER PLANT	PERCENTAGE DAMAGE POD PER PLANT (%)	SEED NUMBER PER POD	GRAIN YIELD (kg/ha)
TG X 923-ZE (V1)	25.00	10.53	5.67	22.77	3.833	2871.8
TG X 579 (V2)	30.20	7.80	6.97	23.07	4.767	3084.2
TG X 1014-ZED (V3)	23.00	9.37	3.13	13.67	3.000	2650.4
TG X 1019 – ZED (V4)	20.43	9.70	4.40	21.50	3.567	2135.5
TG X 360 - OZD (V5)	19.90	11.30	3.53	17.70	3.167	2498.4
TG X 1448 (V6)	27.33	8.67	4.67	17.10	4.100	2969.3
MEAN	24.31	9.56	4.73	19.30	3.739	2701.
LSD (0.05)	1.583	1.441	1.154	5.182	0.5077	125.4
CV (%)	3.2	3.5	3.0	1.6	2.3	1.2

Table 5: *Plant traits, their ranks and rank summation index (RSI) of 6 soybean genotypes*

Genotype	NPPP	R_1	PL	R_2	NDPPP	R_3	PDPPP	R_4	NSPP	R_5	GY	R_6	RSI
TG X 1448 (V6)	27.33	2	8.67	5	4.67	4	17.10	2	4.10	2	2969.3	2	17
TG X 1014-ZED (V3)	23.00	4	9.37	4	3.13	1	13.67	1	3.00	6	2650.4	4	20
TG X 923-ZE (V1)	25.00	3	10.53	2	5.67	5	22.77	5	3.83	3	2871.8	3	21
TG X 579 (V2)	30.20	1	7.80	6	6.97	6	23.07	6	4.77	1	3084.2	1	21
TG X 360 - OZD (V5)	19.90	6	11.30	1	3.53	2	17.70	3	3.167	5	2498.4	5	22
TG X 1019 – ZED (V4)	20.43	5	9.70	3	4.40	3	21.50	4	3.57	4	2135.5	6	25

NPPP = Number of pod per plant, PL = Pod length (cm), NDPPP = Number of damaged pod per plant, Percentage damaged pod per plant, Number of seed per pod, GY = Grain yield (kg/ha), R_1-R_6 = $Rank_1$ to $Rank_6$, RSI = Rank summation index.

Table 6: *Pearson correlation matrix of some yield parameters of 6 soybean genotypes evaluated.*

	(1)PNPP	(2)SNPP	(3)PL	(4)NDPPP	(5)GY
1.Pod no. per plant	1				
2. Seed no. per plant	0.893*	1			
3. Pod length	-0.807	0.759	1		
4. no. of damage pod per plant	0.790	-0.934**	-0.562	1	
5. Grain yield per hectare	0.907*	0.691*	0.535	-0.616*	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

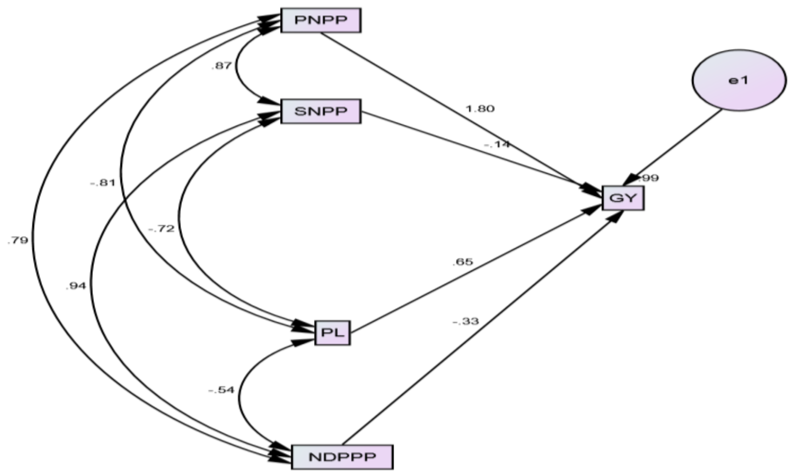

***Figure 1*. Path Diagram**
NDPPP = Number of damaged pod per plant, PL = Pod length, PNPP = Pod number per plant, GY = Grain yield, SNPP = Seed number per plant.