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Identification of Rich Oil-Protein and Disease Resistance Genotypes in Soybean [*Glycine max* (L.) Merrill]

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ABSTRACT

A study was undertaken on oil-protein content and their relation with yield and evaluation of resistance for aerial blight and frog eye leaf spot diseases in soybean during *kharif* (July–December, 2019) at J.N.K.V.V., Jabalpur, Madhya Pradesh, India. The experiment was laid out using augmented block design with 154 genotypes of soybean including four check varieties namely JS 20-34, JS 20-98, JS 335 and NRC 86. Per cent disease severity was measured at peak of disease during seed formation stage (R5-R6). Yield and 100 seed weight were recorded at time of harvesting. Oil and protein content from harvested yield was estimated by using standard methods of association of official analytical chemists (AOAC). The results revealed that oil content varied from 16.8–20.2% and protein content from 36.1–41.2% in all 154 genotypes. Per plant average seed yield (3.9-15.1 g) and hundred seed weight (6.7–14.7 g) were also varied from genotypes to genotypes. The correlation between oil and protein was highly negative ($r=-0.620^{**}$, $p=0.01$). This investigation identified ten genotypes with high oil (>20%) and fourteen genotypes with high protein (>40%) content. Among which JS 20-104, Cat 473B and RKS 24 were higher in protein, and Cat 48, Cat 330 and JS 20–69 were higher in oil content. In disease evaluation, eleven genotypes namely Cat 473B, Cat 60, Cat 642, JS 20–76, JSM 122, JSM 126A, JSM 126B, JSM 203, JSM 287, RKS 66 and SQL 89 exhibited dual resistance for aerial blight as well as frog eye leaf spot were screened out. The result showed that variation in oil-protein content and disease resistance depends on the genotype.

KEYWORDS: Aerial blight, frog eye leaf spot, oil-protein, resistance, soybean

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1. INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] also recognized as "miracle legume" or "yellow jewel" is most widely grown as a self-pollinated eco-friendly crop in the world. Soybean is the richest source of vegetable protein (40%) that also contains a considerable percentage of edible oil (20%) (Agarwal et al., 2013; Mehra et al., 2020). Soybean also contains numerous health beneficial contents such as eight essential amino acids, unsaturated fatty acids, minerals (Ca and P), vitamins (e.g. A, B, C and D), antioxidants, etc which help in lowering cholesterol, enhancing the immune system and ultimately diminish the risk of several diseases in human (Jakhar et al., 2018; Kumar et al., 2020). Presently soybean is the leading oilseed crop in the country and as per 2018–19, India ranks fifth in the area under cultivation (10.83 mha) and production (10.93 mt) of soybean in the world (Anonymous, 2020). USA is the largest producer of soybean followed by Brazil, China and Argentina.

Soybean is highly rich in protein that makes it useful in the preparation of several food items like dal, tofu, besan, soymilk, soy paneer, soy protein powder, soybean de-oiled cake etc (Singh, 2010; Pratap et al., 2012; Chen et al., 2012). Protein and oil content in the seed may be varied from 31.9–45.0% and 14.0–21.7%, respectively under different environment×genotypic conditions (Sathe et al., 2014; Sharma et al., 2014; Finoto et al., 2021). Being a successful and mega oilseed crop, productivity is still hovering around 1.2 t ha^{-1} despite the yield potential of up to 3.5 t ha^{-1} (Mishra et al., 2018). The existence of a negative correlation between protein and oil content in soybean grains has prevented the simultaneous increase of these characters in commercial lines (Hill et al., 2004; Clemente et al., 2009; Purcell et al., 2014). Besides this, biotic stresses particularly diseases are continuously becoming a major challenge and reducing the yield of several mega varieties in the major pocket of soybean growing areas in India (Amrate et al., 2019, 2020; Rajput et al., 2022). Foliar diseases *i.e.* Aerial blight (*Rhizoctonia solani*) and Frog eye leaf spot (*Cercospora sojina*) are important yield reducing factors in different parts of the country. Aerial blight is a very severe disease that causes significant yield loss and reduced 41.45% yield of soybean on 55.5% disease severity (Amrate et al., 2021a). Aerial blight causes light to dark brown spots, web like mycelium on foliage and formed sclerotia on above ground parts (Kumari et al., 2021; Amrate et al., 2021b). In case of frog eye leaf spot, infected leaves have irregular spot with reddish brown margins and ash gray centers. Frog eye leaf is wide spread disease of soybean and pathogen (*Cercospora sojina*) produces hyaline, straight, and multiseptate conidia from clustered conidiophores on infected tissue (Yang et al., 2001; Zhang et al., 2018). Increased knowledge about the location and quantity of the pathogen in relation to weather conditions provides numerous benefits to growers and researchers by providing more accurate timing of disease management. Identification and incorporation of resistance in high yielding genotypes is the best way to minimize the losses caused by diseases (Amrate et al., 2018; Rajput et al., 2022).

Looking at all these facts, the present investigation was carried out to determine rich oil protein content and disease resistant genotypes so that it could be utilized in overall genetic crop improvement as well as for soybean processing industries directly.

2. MATERIALS AND METHODS

One hundred fifty four genotypes of soybean including four check varieties *viz.*, JS 20–34, JS 20–98, JS 335 and NRC 86 were sown in augmented block design (Federer, 1956) with keeping plot size of 0.5m×3.0 m^2 in the experimental field of AICRP on Soybean, J.N.K.V.V., Jabalpur, Madhya Pradesh (Latitude: 23º14 N, Longitude: 79º56 E, Altitude: 411.5 m) during *Kharif*, July to December 2019. In an augmented block design, the test treatments were replicated once and check varieties appear exactly once in each block. Likewise, in total six blocks every check was replicated after each 25 of genotypes. Seeds of the genotypes collected from AICRP on soybean, Jabalpur. After emergence thinning was done to optimize plant to plant distance 6–8 cm and other operations were also followed as per the recommended packages and practices except applying disease protection measures.

At the time of harvesting, seeds were collected from competitively healthy plants and subjected to oil-protein extraction. The oil content was determined by the procedure described in Soxhlet extraction method (Anonymous, 1984) as 5g sample was weighed accurately, placed in a thimble and plugged with cotton. The extractor-containing thimble was placed over a pre-weighed extraction flask (A). Oil content was determined by extracting the sample with solvent petroleum ether (AR grade 60–80°C) for 8hr using the Soxhlets extraction procedure. After extraction, the excess solvent was distilled off and the residual solvent was removed by heating at 80°C in the oven for 4–6 hr. the flask was weighted (B) and the oil content was determined as crude oil.

Crude oil (%)=(Weight of flask (B) - Weight of flask (A)/ Weight of sample)×100

Protein content was determined by the conventional Micro-Kjeldahl digestion and distillation method (Anonymous, 1984). The sample (0.2 g) was weighed accurately and transferred to a Kjeldahl flask. The catalyst mixture (100g K_2SO_4, 20g of $CuSO_4$ and 2.5g of SiO_2) of 1g and concentrated sulphuric acid (10 ml) were added. Then the flask was heated in the digestion chamber for about 4–6 hr. till the liquid became clear green blue color. For distillation the content in the flask was transferred quantitatively to a vacuum jacketed flask of micro Kjeldahl distillation apparatus and the ammonia liberated by the addition of 25ml of 40%NaOH on heating was absorbed in 25ml of boric acid containing 2-3 drops of mixed indicator in 100 ml conical flask. The distilled off ammonia was titrated against 0.1N sulphuric acid and reading at pink color change was recorded. The blank was also run in a similar way.

N (%)=(Normality of H_2SO_4xVolume of 0.1N H_2SO_4x14/Weight of samplex1000) ×100
Crude protein (%)=N % x 6.25

Rhizoctonia Aerial Blight (RAB) and frog eye leaf spot (FLS) were two important diseases that usually affect soybean varieties/genotypes every year with varying intensity at experimental locations. The experimental location is hot spot for Aerial blight of soybean. It is appear every year and favours by high humidity and moderate temperature (Amrate et al., 2021b). Atmospheric mean temperature at experimental location was moderate (22.4-30.3°C). Whereas the rainfall (around 1500 mm) and RH (>80 %) were high as compare to previous season. High rainfall and humid weather during cropping season at the experimental site were also created favorable conditions for disease development of Aerial blight as well as Frog eye leaf spots. Hence, all these genotypes were critically observed for both diseases throughout the season and 0-9 ratings/grades based on the percent leaf area infected were given on randomly selected 10 ten plants (5–6 leaves from each plant) between seed formation to full seed stage (R5-R6) (Anonymous, 2019; Amrate et al., 2021a). Severity ratings (0-9) of Aerial blight and Frog eye leaf spot used are described as 0= no lesions/spots, 1=1% leaf area covered with lesions/spots, 3= 1.1 –10% leaf area covered with lesions/spots, no spots on the stem, 5=10.1–25% of leaf area covered, no defoliation; little damage, 7=25.1–50% leaf area covered; some leaves drop; death of a few plants, damage conspicuous and 9= more than 50% area covered, lesions/spots very common on all plants, defoliation common; death of plants common; damage more than 50%. Per cent Disease index (PDI) was calculated utilizing the above severity ratings and Wheeler's (1969) formula as given below

PDI={Sum of individual rating/(Number of examined leaves×Maximum disease rating)}×100

On the basis of PDI, the genotype/variety were designated as Absolutely resistant (0.0), Highly Resistant (0.1–1.0), Moderately resistant (1.1–10.0), Moderately susceptible (10.1– 25.0), Susceptible (25.1 – 50.0) and highly susceptible (> 50.0) (Anonymous, 2019; Amrate et al., 2021a).

3. RESULTS AND DISCUSSION

3.1. Yield and 100 seed weight of genotypes

Yield performance and its contributing trait were evaluated under field conditions of high diseases pressure and along with adverse weather i.e. higher rainfall. In these conditions, plant^{-1} average seed yield (3.9–15.1 g) and hundred seed weight (6.7–14.7 g) were varied from genotypes to genotypes (Table 1 and Figure 1). Despite of yield variation, 16 genotypes i.e. ERS 1344 (10.26), GP 448 (15.14), JS 20-89 (13.06), JS 20-108 (12.6), JSM 122 (11.4), JSM 126A (13.2), JSM203 (13.4), JSM 227 (12.8), JSM 284 (11.1), JSM 285 (13.66), KBS 701 (10.4), NRC 124 (13.7), RVS 2010-2 (13.12), VLS 58 (14.8), JS 335* (11.63) and NRC 86* (13.32) recorded higher yield (>10g seed yield per plant). The highest seed size >12 g (100 seed weight) was recorded in Cat 1958 (12.41), GP 448 (12.92), JS 20-06 (12.93), JS 20-113 (12.72), JSM 285 (13.84), KS 103 (12.46), MAUS 706 (12.11), NRC 2324 (14.73), SQL 31 (12.09). Amrate and Shrivastava (2021) evaluated 38 promising soybean genotypes at Jabalpur conditions and reported that yield performance was varied among genotypes and highly influenced by the complex of diseases.

3.2. Oil -protein content

Oil-protein estimation revealed that different genotypes had different content. In 154 genotypes, oil and protein content were ranged from 16.8–20.2 and 36.1–41.2%, respectively (Table 1). It was identified that ten genotypes Cat 330, Cat 418, JS 20-68, JSM 139, SQL 32, PK 618, JSM 298, JS 98-66, JS 20-68 and JS 20-70 had high oil (>20%). Whereas fourteen genotypes namely Cat 473B, JS 20-104, JS 20-108, JSM 126B, JSM 126A, RKS 24, MACS 45, ERS 1344, JSM 170, RKS 18, JSM 276, JS 20-110, IC 313230 and B327had high protein content (>40%). However the average oil and protein content was 18.75 and 38.04%, respectively. Genotypic variations in soybean oil protein content were also reported by several researchers such as Finoto et al. (2021) 17.06–19.74% (oil) and 34.48–40.62 % (protein); Malik et al. (2021) 30.21–39.7% (protein) and 17.4–22% (oil).

Correlation coefficient values revealed that the relation between oil and protein was highly negative ($r=-0.620^{**}$, $p=0.01$). The correlation of seed yield with oil and protein was positive (0.015) and negative (-0.023), respectively (Table 2). Hundred seed weight also had a similar positive and negative correlation with oil (0.064) and protein (-0.140). The significant negative relation between oil and protein content in soybean was also reported by several researchers (Sharma et al., 2008; Rao and Reddy, 2010).

Table 1: Yield, 100 seed weight, Oil- protein content and disease resistance reaction for *Rhizocotonia* aerial blight (RAB) and Frog eye leaf spot (FLS) in 154 genotypes

Sl. No.	Genotype	Seed yield plant^{-1} (g)	100 seed weight (g)	Oil (%)	Protein (%)	Disease reaction	
						RAB	FLS
1.	AGS 80	7.6	8.29	18.9	38.3	MR	HR
2.	AGS 112	7.1	10.12	19.1	39.4	MR	MS
3.	AMS 243	7.11	9.83	19.8	36.2	MS	MS
4.	B 327	4.2	8.91	17.8	40.0	MR	MR
5.	BAUS 102	5.6	9.38	19.4	37.2	MR	MR
6.	Cat 156	5.45	10.35	19.9	36.2	MR	MR
7.	Cat 330	5.83	10.6	20.1	38.6	MR	HR
8.	Cat 418	8.61	10.17	20.2	37.3	MS	MR
9.	Cat 473B	6.4	11.09	17.8	40.2	HR	HR
10.	Cat 488	6.8	10.8	18.9	38.2	MS	MS
11.	Cat 60	5.46	9.81	19.4	37.8	HR	HR
12.	Cat 642	4.8	10.07	18.9	38.3	HR	HR
13.	Cat 1328	5.6	7.74	19.5	37.1	MR	MR
14.	Cat 1843B	4.49	9.55	19.7	38.4	HR	MR
15.	Cat 1957	9.66	9.73	17.6	37.7	HR	MR
16.	Cat 1958	5.2	12.41	18.8	37.3	HR	MS
17.	Cat 2059	4.9	10.56	18.6	36.4	MS	MR
18.	Cat 2086A	7.6	10.76	19.1	38.6	MR	HR
19.	Cat 2090	6.1	10.83	19.2	39.3	MS	HR
20.	Cat 2127B	4.94	8.52	18.7	37.7	MR	MS
21.	DSB 1	5.7	8.83	17.8	39.3	MS	MS
22.	DSB 25	8.1	8.28	18.1	37.5	MS	MR
23.	Eagle 81	7.97	10.26	19.2	39.6	MS	MR
24.	ERS 9045	6.4	11.06	18.4	38.0	S	S
25.	ERS 1344	10.26	10.84	17.9	40.1	S	MR
26.	EC 456647	9.16	11.45	19.7	35.9	MR	MR
27.	GP 448	15.14	12.92	18.6	36.5	MR	MR
28.	GP 465	4.56	8.77	19.4	37.7	MR	MS
29.	G 225	4.8	9.35	18.2	38.3	HR	MR
30.	Himso 1681	3.86	9.86	19.2	36.9	MR	MR
31.	Hara soya Eagle	5.8	7.92	17.3	39.9	MS	MR
32.	IC 313230	5.9	9.77	17.8	40.0	MS	S
33.	JS 71-05	5.5	8.45	19.2	38.2	S	S
34.	JS 72-44	5.7	9.58	19.6	37.2	MR	MR
35.	JS 75-30	6.2	10.39	18.9	36.5	MS	MR
36.	JS 75-46	4.8	8.07	18.8	38.2	S	MS
37.	JS 97-57	5.3	10.74	19.4	37.2	MR	MR

Table 1: Continue...

Sl. No.	Genotype	Seed yield plant^{-1} (g)	100 seed weight (g)	Oil (%)	Protein (%)	Disease reaction	
						RAB	FLS
38.	JS 98-66	6.69	10.97	20.1	35.9	S	MS
39.	JS 99-77	5.4	9.83	18.7	36.3	MR	MR
40.	JS 99-88	4.93	8.96	19.1	36.9	MR	HR
41.	JS 20- 06	5.56	12.93	17.9	39.7	HR	MR
42.	JS 20-15	4.49	10.05	18.3	37.5	HR	MR
43.	JS 20-16	8.62	9.58	19.4	38.1	MR	MR
44.	JS 20-25	4.9	8.65	18.8	37.4	MR	MR
45.	JS 20-32	6.8	8.96	19.5	38.0	MR	MR
46.	JS 20-55	6.2	9.46	18.2	37.1	MR	MR
47.	JS 20-63	4.9	10.14	19.1	38.2	MS	MS
48.	JS 20- 66	5.6	9.3	19.9	37.7	MR	MR
49.	JS 20-68	8.3	10.47	20.1	37.4	MS	S
50.	JS 20-72	6.64	8.51	20.0	37.2	MR	MR
51.	JS 20- 74	8.2	8.67	17.2	39.8	MR	HR
52 .	JS 20-77	5.45	10.9	18.7	37.4	S	MR
53.	JS 20-81	4.85	9.45	17.8	39.8	MR	MR
54.	JS 20- 86	4.9	9.39	18.4	37.2	MR	HR
55.	JS 20-89	13.06	14.75	18.9	37.5	MR	MR
56.	JS 20-91	8.7	10.84	19.6	37.7	MR	MR
57.	JS 20- 96	9.6	11.61	19.1	36.2	MR	AR
58.	JS 20-97	6.7	11.33	18.8	37.5	MR	S
59.	JS 20-100	5.3	9.13	19.8	37.4	MR	MS
60.	JS 20- 104	7.43	9.25	16.8	41.2	HR	MR
61.	JS 20-108	12.6	9.75	17.1	40.7	MS	HR
62.	JS 20-109	5.41	9.55	18.2	37.8	MS	HR
63.	JS 20-110	4.26	9.33	17.4	40.0	MS	HR
64.	JS 20- 113	6.7	12.72	18.7	38.2	MS	HR
65.	JS 20-03	5.8	11.18	17.9	39.8	MS	MS
66.	JS 20-09	4.9	9.68	18.2	37.8	MS	HR
67.	JS 20-76	5.42	10.04	19.1	37.2	HR	HR
68.	JSM 3	4.75	11.68	18.8	39.0	MR	MR
69.	JSM 7	5.2	9.53	18.4	39.3	MR	MS
70.	JSM 17	6.1	10.18	19.1	36.4	MR	S
71.	JSM 122	11.4	10.51	19.0	37.3	HR	AR
72.	JSM 126A	13.2	7.83	17.2	40.1	HR	AR
73.	JSM 126B	4.94	9.62	16.9	40.1	HR	HR
74.	JSM 127	9.8	9.42	18.1	37.7	MR	MR
75.	JSM 139	8.3	7.13	20.1	37.3	MS	MR
76.	JSM 155	6.8	9.29	17.4	39.8	MS	S

Table 1: Continue...

Sl. No.	Genotype	Seed yield plant^{-1} (g)	100 seed weight (g)	Oil (%)	Protein (%)	Disease reaction	
						RAB	FLS
77.	JSM 170	4.8	8.09	16.9	40.1	MS	S
78.	JSM 188	4.7	9.02	19.4	38.3	MR	MS
79.	JSM 202	5.45	8.26	19.6	38.4	MR	MR
80.	JSM 203	13.4	9.63	18.1	37.2	HR	AR
81.	JSM 224	6.71	8.79	17.8	39.7	MR	MR
82.	JSM 226	5.6	8.62	18.5	37.2	MS	MR
83.	JSM 227	12.8	8.62	19.6	36.9	MR	MR
84.	JSM 228	7.26	10.37	18.1	38.2	HR	MR
85.	JSM 230	6.81	10.98	17.8	38.8	HR	MS
86.	JSM 232	5.8	7.73	19.4	38.1	MR	MR
87.	JSM 236	11.7	11.91	19.8	37.8	MR	HR
88.	JSM 259	9.0	10.56	17.8	38.4	HR	MS
89.	JSM 265	7.9	7.96	18.7	39.2	MS	MS
90.	JSM 276	5.8	9.27	17.6	40.1	MS	MR
91.	JSM 284	11.1	9.76	18.5	37.5	MR	MR
92.	JSM 285	13.66	13.84	19.4	38.1	HR	MR
93.	JSM 287	5.8	8.34	18.8	37.3	HR	HR
94.	JSM 288	8.67	11.56	19.2	36.7	MR	MR
95.	JSM 298	5.7	8.52	20.2	37.4	S	MR
96.	JSM 301	8.3	10.02	19.8	38.1	MR	MR
97.	JSM 302	6.26	9.94	18.7	37.4	MR	MR
98.	JSM 310	8.7	10.13	17.6	39.3	HR	MS
99.	JS 335×G.Soja2	4.2	8.19	18.7	37.8	MS	MS
100.	KS 103	6.44	12.46	19.3	38.1	MR	MR
101.	KBS 701	10.4	10.26	19.8	36.5	HR	MR
102.	MACS 453	8.8	9.57	17.8	40.2	MR	MR
103.	MACS 1442	6.2	10.21	18.5	37.4	S	S
104.	MAUS 71	4.7	10.25	18.8	36.5	MS	MR
105.	MAUS 162	4.94	9.62	19.8	37.2	MR	MR
106.	MAUS 706	6.2	12.11	18.4	37.1	S	MS
107.	MAUS 1460	6.9	11.05	17.9	39.6	S	MS
108.	Nagaland 2	6.7	8.55	19.6	38.2	MR	MR
109.	NRC 2	4.45	9.4	18.9	38.0	MR	MS
110.	NRC 7	6.3	10.71	18.2	36.6	S	MR
111.	NRC 29	4.8	9.23	18.4	39.8	MS	MR
112.	NRC 37	8.9	10.04	19.2	36.2	MR	MR
113.	NRC 67	4.28	9.44	19.6	37.8	MR	MS
114.	NRC 76	4.42	8.61	17.6	39.8	MS	MS
115.	NRC 84	6.32	11.15	18.2	36.8	MR	MR

Table 1: Continue...

Sl. No.	Genotype	Seed yield plant^{-1} (g)	100 seed weight (g)	Oil (%)	Protein (%)	Disease reaction	
						RAB	FLS
116.	NRC 99	5.29	9.62	18.8	37.4	MR	MR
117.	NRC 116	6.4	10.81	17.9	39.9	MS	MR
118.	NRC 124	13.7	11.77	19.5	37.8	HR	MS
119.	NRC 2324	5.6	14.73	19.1	38.0	MR	MR
120.	PI 204336	7.6	9.0	18.2	37.6	MR	AR
121.	PS 7	5.4	9.79	18.7	38.1	MR	MR
122.	PS 1423	6.9	7.88	18.1	37.5	MS	MS
123.	PS 1569	5.4	8.57	19.7	36.2	MR	MR
124.	PK 462	7.3	9.35	19.8	35.3	MS	MR
125.	PK 618	5.1	10.65	20.1	36.1	MR	HR
126.	PK 1092	4.8	12.47	19.2	37.1	MR	MR
127.	PK 1171	4.79	10.26	18.9	37.5	MS	MR
128.	RKS 18	5.62	10.95	17.8	40.1	MS	MS
129.	RKS 24	5.8	8.55	16.9	40.2	MS	MS
130.	RKS 39	4.7	9.28	17.5	39.0	S	MS
131.	RKS 47	5.1	9.2	18.7	38.2	MR	MR
132.	RKS 66	5.9	10.15	18.1	37.9	HR	HR
133.	RSC 10-70	7.1	9.54	19.1	38.2	MS	MR
134.	RSC 10-71	6.9	10.04	18.8	37.0	MS	MR
135.	RVS 2007-6	6.1	8.95	19.7	37.4	S	HR
136.	RVS 2009-9	9.2	11.56	18.7	38.1	MR	MR
137.	RVS 2010-2	13.12	11.41	18.2	37.5	MR	MR
138.	RVS 2011-4	7.0	9.04	19.3	38.1	MR	MR
139.	SL 742	5.0	10.72	18.7	37.4	MS	MR
140.	SL 1028	5.28	11.65	18.6	37.8	MS	MS
141.	SL 1104	6.43	10.0	17.8	39.0	MS	MR
142.	SKFSPC 11	5.2	10.08	18.4	36.7	MR	MR
143.	SQL 31	9.31	12.09	19.5	38.1	MR	MR
144.	SQL 32	5.8	8.55	20.1	36.6	S	MR
145.	SQL 89	8.47	10.04	18.8	37.5	HR	HR
146.	TS 37	5.8	10.82	19.2	37.6	MS	HR
147.	VLS 58	14.8	10.47	18.7	38.2	MS	MS
148.	VLS 69	4.2	6.7	18.5	37.5	MR	MR
149.	VLS 89	6.38	9.57	17.9	39.6	S	MS
150.	WT 88	5.53	10.3	18.9	37.2	HR	S
151.	JS 20-98*	6.09	8.97	19.4	39.6	MR	MR
152.	JS 20-34*	6.82	7.7	19.8	39.9	MR	MR
153.	JS335*	11.63	9.18	19.4	38.1	S	MS
154.	NRC-86*	13.32	9.53	18.9	39.1	MR	MR

Table 2: Correlation coefficient matrix between oil-protein, yield attributing traits and seed yield (based on 154 genotypic values)

Variables	Seed yield	100 seed weight	Oil	Protein
Seed yield	1	0.273**	0.015	-0.023
100SW	0.273**	1	0.064	-0.140
Oil	0.015	0.064	1	-0.620**
Protein	-0.023	-0.140	-0.620**	1

**: Highly significant (p=0.01), *: Significant (p=0.05)

Our finding was similar to Baldwin and Fulmer (2022) who also reported a negative association (r = −0.17) between seed yield and protein.

3.3. Resistance screening

Aerial blight and frog eye leaf spot both the disease appeared in second fortnight of August during flowering stage of crop (R1-R2). Disease progression was continued and final scoring for resistance was accomplished at seed formation stage (between R5 to R6). The result of screening of 154 genotypes revealed disease reactions for Aerial blight and Frog eye leaf spot were varied from Absolute resistant to Susceptible for different genotypes (Table 1, Figure 2). Screening against Rhizoctonia aerial blight (RAB) showed the severity of disease during the month of August and it was continued till the harvesting of the crop. Out of 154, there were 26 genotypes namely Cat 473B, Cat 60, Cat 642, Cat 1843B, Cat 1957, Cat 1958, G 225, JS 20- 06, JS 20-15, JS 20- 104, JS 20-76, JSM 122, JSM 126A, JSM 126B, JSM 203, JSM 228, JSM 230, JSM 259, JSM 285, JSM 287,JSM 310, KBS 701, NRC 124, RKS 66, SQL 89, WT 88 exhibited absolute and highly resistant reaction resistant (PDI=<1.0). The incidence of frog eye leaf spot

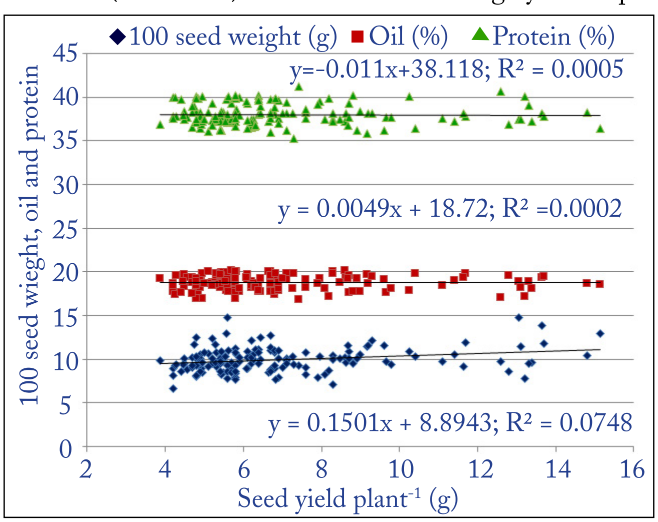

Figure 1: Effect of seed yield on 100 seed weight, oil (%) and protein (%) in soybean

Figure 2: Typical symptoms diseases: Greyish water soaked lesion of Rhizoctonia aerial blight (A) and Frog eye leaf spots with dark brown margins and ashy grey centre (B) and view of RAB susceptible genotype (C), respectively

was observed during the vegetative stage and continued till the harvesting of the crop. Amongst all, total twenty four genotypes namely AGS 80, Cat 330, Cat 473B, Cat 60, Cat 642, Cat 2086A, Cat 2090, JS 99-88, JS 20- 74, JS 20- 86, JS 20-108, JS 20-109, JS 20-110, JS 20- 113, JS 20-09, JS 20-76, JSM 126B, JSM 236, JSM 287, PK 618, RKS 66, RVS 2007-6, SQL 89, TS 37 recorded absolute and highly resistant reaction against Frog eye leaf spot.

However, out of this, only eleven genotypes namely Cat 473B, Cat 60, Cat 642, JS 20-76, JSM 122, JSM 126A, JSM 126B, JSM 203, JSM 287, RKS 66 and SQL 89 were found to be absolutely/highly resistant to both diseases of soybean. Amrate et al. (2018, 2020) also reported different level of resistance and identified few genotypes as highly resistant against aerial blight. Khati et al. (2011) and Kim et al. (2018) were recorded various level of resistance and host differential against frog eye leaf in soybean.

4. CONCLUSION

Ten genotypes were identified as high oil (>20%) and fourteen genotypes were with high protein (>40%) content. These genotypes could be utilized for preparing different soya products as well as in crossing for further quality enhancement. Along with this, eleven genotypes (Cat 473B, Cat 60, Cat 642, JS 20-76, JSM 122, JSM 126A, JSM 126B, JSM 203, JSM 287, RKS 66 and SQL 89) were identified as resistant source for both the diseases. i.e. aerial blight plus frog eye leaf spot in soybean.

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