The present research work was undertaken during 2001 – 2005 at the Centre for Bioresources and Biotechnology, TERI School of Advanced Studies, New Delhi to transfer resistance/ tolerance to white rust and alternaria blight from *Brassica rapa* and *Brassica carinata* to *Brassica juncea* through *in vitro* embryo rescue as well as *in vivo* seed set. Interspecific hybrids of *B. juncea* × *B. rapa*/*B. carinata* were grown and characterized using morphological and molecular markers to assess the variability for both the diseases. The selected plant progenies were advanced and screened for agro-morphological traits and biochemical parameters with varying degree of diseases response. Two genotypes RESBR 219 and RESBR 350 of *B. rapa* resistant to *Peronospora parasitica* and *Albugo candida* race 2 and var. Kiran of *B. carinata* resistant to white rust and tolerant to alternaria blight were selected. The *B. juncea* genotypes selected for resistance to *P. parasitica* and *A. candida* race 7 were RESBJ 830 and RESBJ 837, while TERI (OE) M21-1 was selected for improved nutritional oil quality profile (low erucic acid and high oleic acid). The salient findings of the present research work are summarized as follows:

Putative hybrids were obtained through *in vivo* (4.7%) and *in vitro* (2.4%) techniques with the majority of hybrids being produced through ovule culture. Post fertilization barriers existed in *in vivo* seed germination and required an *in vitro* phase for establishment of hybrid seedlings. More hybrids were obtained with the amphidiploid (6.5%) species as male donor than diploid species (2.1%). ISSR markers confirmed the hybrid nature of the plantlets. Morphologically hybrids were intermediate to their parent genotypes but with male donor identifying features in the *B. juncea* × *B. carinata* cross.

The parent genotypes of *B. juncea* and *B. rapa* showed a differential response to *A. candida* isolates; with the former being resistant to field isolate of *A. candida* derived from *B. rapa* and the latter moderately resistant to *B. juncea* field isolates. *Brassica juncea* var. Varuna, parent genotype TERI (OE) M21-1 as well as *B. rapa* var. Pusa Gold were susceptible or moderately susceptible to all the isolates, whereas *B. carinata* genotype Kiran was resistant to all the field isolates under controlled epiphytotic conditions. *Brassica juncea* isolate collected at Delhi (AcBjD) was more virulent as compared to the Pantnagar isolate (AcBjP). Overall, host-pathogen response was greater using the mixture of isolates than...
the individual isolates. Both alternaria blight fungal toxin and pathogen suspensions distinguished between *B. juncea* and *B. carinata* categorizing them as susceptible and resistant respectively. However, different *B. juncea* genotypes gave differential disease response when inoculated with conidial suspension but showed a similar moderately resistant disease reaction on interaction with crude fungal toxin of alternaria blight.

F₂ and BC₁ plants of the cross *B. juncea* x *B. rapa* produced 67.6% and 80.0% *B. juncea* type plants while all plants in *F₃* and *F₂BC₁*, *BC₁F₂* and *BC₂* generations resembled the female parent with partial characteristic of the male donor evident in *F₃* and *BC₁F₂*. Hybrids from the cross *B. juncea* x *B. rapa* were resistant to white rust (DI<1.0) but differed in their disease response in subsequent generations. *F₃* and *F₂BC₁* plants showed no visible disease symptoms. DI increased from BC₁ (1.53) to BC₁F₂ (1.86) and BC₂ (2.48) in the cross combination involving parent genotype RESBJ 830, while there were no differences in DI of BC₁ (1.41), BC₁F₂ (1.28) and BC₂ (1.75) plants in crosses involving RESBJ 837. The resistance was either equal to the male donor or superior to both the parents. Overall, a higher number of resistant plants were obtained from the cross combination RESBJ 837 x RESBR 219 than the cross RESBJ 830 x RESBR 350. A total of 76 resistant plants (DI≤1.0) having *B. juncea* type morphological characteristics were selected from the *F₃* and *F₂BC₁*, *BC₁F₂* and *BC₂* generations. A positive correlation was observed between growth stages of plants and white rust disease infestation in all generations as the disease progressed from 75 to 90 DAS (r=0.93) and from 90 to 110 DAS (r>0.97) under field conditions.

F₂ and BC₁ populations of *B. juncea* x *B. carinata* cross had 72% intermediate and 60% *B. juncea* type plants. The plants from cross combination involving RESBJ 837 and TERI (OE) M21-1 were *B. juncea* type in BC₁F₂ and BC₂. On the other hand, plants from the cross combination RESBJ 830 showed intermediate morphology in BC₁F₂ and *B. juncea* type BC₂ plants with strong male donor characteristics like short main branch. A characteristic red dot present at the tip of anthers on hybrids was observed on F₂ plants. The red dot presence diminished with successive advanced generations (BC₁, BC₂ and BC₁F₂). The presence of purple colour inherited from the male donor was observed in all the generations. Plant progenies with TERI (OE) M21-1 as female parent were brown seeded in all generations, whereas plant progenies involving RESBJ 837 and RESBJ 830 segregated into yellow and brown seeded plants in the ratio of 10:19 in BC₁, 5:42 in BC₁F₂ and 10:7 in BC₂.
Hybrids, $F_2$ and $BC_1$ plants from the cross *B. juncea* x *B. carinata* showed only a few visible disease symptoms for white rust. The $BC_1$ plants from all three cross combinations were tolerant to alternaria blight at both the mature leaf growth stage and the pod formation stage. An equivalent disease response was observed in plants derived from cross combinations involving the female genotypes RESBJ 830 (0.81) and RESBJ 837 (0.94). These were superior to the plants obtained from cross combination involving TERI (OE) M21-1 (1.47) as female parent. All the $BC_1$ plants exhibited a higher resistance than their respective female parents (>3.4). The $BC_2$ plants from these three different *B. juncea* genotypes did not show variation in average disease response at the mature leaf growth stage and were resistant to white rust (average $DI <1.0$) and alternaria blight ($DI<2.0$). In all the generations, the proportion of plants resistant to white rust was higher (79.16-100%) and consistent as compared to the varying proportions of the populations resistant to alternaria blight (7.50% in $F_2$ to 100% in $BC_2$). Overall, plants with the female genotype RESBJ 837 exhibited a higher resistance to both white rust and alternaria blight as compared to the plants with the genotype TERI (OE) M21-1K followed by RESBJ 830. A total of 69 $BC_1F_2$ and $BC_2$ *B. juncea* type plants were selected with resistance to white rust ($DI \leq 1.0$) and alternaria blight ($DI<2.0$).

The $BC_1F_2$ and $BC_2$ plants obtained from two different cross combinations of the cross *B. juncea* x *B. rapa* did not differ for important yield traits and tended to resemble the female parent. The $F_2$,$BC_1$ and $BC_2$ were equivalent to the female parent for important yield attributing traits including 1000 seed weight. The fatty acid profile of seeds of these plants resembled their female parent with high erucic and low oleic acid content but one plant from each of the $BC_1F_2$ and $BC_2$ populations showed moderately low glucosinolate content of 45.55 µmol/g meal.

The $BC_1F_2$ plants from cross *B. juncea* x *B. carinata* resembled either the male donor (RESBJ 830 x Kiran) or were intermediate between the parents (RESBJ 837/ TERI (OE) M21-1 x Kiran). The $BC_2$ progenies were equivalent to and resembled the female parent for >50% of the agronomic traits, including days to maturity, number of pods on main shoot and 1000 seed weight. The exception was seeds per pod which was highest in the cross involving RESBJ 837 (16 seeds) followed by TERI (OE) M21-1 (14 seeds) and RESBJ 830 (6 seeds). The fatty acid profile and glucosinolate content of plants involving RESBJ 830 and RESBJ 837 was similar to their female parents with high erucic and low oleic acid content as well as high glucosinolate content, while significant desirable variation was observed in the plants from TERI (OE) M21-1 in all generations.
The F2 plants obtained from TERI (OE) M21-1 showed desirable low glucosinolate content (<30 µmol/g meal) in three plants and moderately low in 12 plants (<60 µmol/g meal) (42.8%). The fatty acid profile in seeds of BC1 disease tolerant plants indicated a transition towards the female parent with three plants exhibiting high oleic acid (40.0 to 43.0%) and low erucic acid (1.2 to 5.0%) content. An unexpected, low glucosinolate content in seeds of three plants (13.5 to 29.0 µmol/g meal) and moderately low levels in seven plants (30-60 µmol/g meal) were identified along with tolerance to white rust (DI<1.0). A white rust tolerant BC1 plant with unusually high levels of palmitic (17.48%) and stearic acid (10.62%), along with moderately low oleic (15.0%) and erucic acid (25.0%) as well as low glucosinolate content of 29.04 µmol/g meal was also identified. The fatty acid profile of BC1F2 and BC2 progenies of this cross resembled the female parent with low erucic (<1.0%) and high oleic acid content (>44.0%) along with tolerance to white rust and alternaria blight.

No correlation was observed between erucic acid and the disease response to white rust (r=0.21) or alternaria blight (r=0.19) nor between glucosinolate content and the response of plants to white rust (r=0.19) and alternaria blight (r=0.22).

It is concluded that hybrids can be obtained from B. juncea x B. rapa/ B. carinata under in vivo conditions but require an in vitro phase for seedling establishment. The ISSRs utilized for studying hybrid nature indicated the applicability of ISSR markers in parentage studies as an efficient tool for screening wide hybrids in Brassica species. To the best of our knowledge, till date no published report is available on this aspect. On the whole, 76 B. juncea type plants were selected for white rust resistance (DI ≤1.0; less than 5% leaf area covered with white rust pustules) from advanced generations of the cross B. juncea x B. rapa along with resistance to Peronospora parasitica under natural field conditions. Similarly, 69 B. juncea type plants were selected for both white rust (DI<1.0) and alternaria blight resistance (DI < 2.0; less than 10% leaf area covered with alternaria blight symptoms) from the cross B. juncea x B. carinata.

The important outcomes of the present research were identification of B. juncea type plants with

1) White rust resistant/ tolerant B. juncea plants from two different resistant sources of white rust, B. rapa and B. carinata
2) Combined resistance/ tolerance in B. juncea plants to both white rust and alternaria blight from B. carinata
3) High tolerance to both the fungal diseases combined with yellow seed coat colour in B. juncea
Summary and Conclusion

4) Nutritionally desirable fatty acid profile (low erucic and high oleic acid content) along with disease tolerance to white rust and alternaria blight in *B. juncea*.

Since incorporation of resistance to fungal diseases is economically and environmentally important for increasing productivity, besides minimizing the use of fungicides, these novel elite genotypes with adequate disease resistance traits and nutritionally desirable oil quality profile identified in the present study can be utilized for developing nutritionally improved quality *B. juncea* cultivars with white rust and alternaria blight resistance, for nutritional security in an environment friendly manner.