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Facets of Interspecific Hybridization within Edible *Allium*

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SUMMARY

Since ages, interspecific hybridization has been an important tool in Alliaceae family. It is one of the predominant breeding method for widening genetic variation within edible Allium especially bulb onion, garlic, leek, shallot and Japanese bunching onion and in distant vegetable Allium species. Interspecific hybridization is considered as one of the most pre-eminent methods in developing new varieties as well as transferring useful agronomic traits from one species to another and from wild relatives. Using such technique, important metabolites, cytoplasmic male sterility, disease and pest resistance have been transferred to other Allium species. The review sums up aspects and directions of interspecific hybridization of edible *Allium*.

INTRODUCTION

Throughout the centuries, species hybridization has been used as a means of accelerating genetic variation. It is a compelling method of generating new varieties within a short span of time and transferring useful agronomic traits from one species to another and from wild relatives. The genus *Allium* comprises about 700 species of which onion (*Allium cepa* L.), garlic (*Allium sativum* L.), leek (*Allium porrum*), wild leek (*Allium ampeloprasum* L.) and Japanese bunching onion (*Allium fistulosum* L.) are the most important cultivated vegetable species. Onion and garlic are grown and consumed worldwide, while Japanese bunching onion in East Asia and leek in Europe. Genetic improvement not only involves intraspecific, but also interspecific hybridization, and is the preponderant breeding methods for onion, Japanese bunching onion and leek. Garlic improvement is hastened by clonal selection. Important traits like disease resistance are introgressed usually via backcrossing F_1 hybrids to the required species. However, techniques of such hybridization with other species of genus *Allium* is used often in increasing genetic variability within onion, leek, Japanese bunching onion and garlic.

New CMS sources

Production of onion hybrid seeds is highly relied on cytoplasmic male sterility. Achieving new CMS sources is one of the best way of broadening cytoplasmic gene pool in breeding edible *Allium* species especially in onion. Yamashita *et al*., (1999) observed that cytoplasm obtained from *A. galanthum* might be useful to derive male sterile lines of *A. fistulosum*. Hybrids obtained from *A. galanthum* × *A. fistulosum* exhibited intermediate flowering time and morphological traits to those of parental plants. F_1 plants of *A. galanthum* × *fistulosum* revealed mean pollen fertility of about 65%, but pollen fertility in BC_1 and BC_2 and its subsequent backcross generations (upto BC_5) were found pollen sterile. Furthermore, Yamashita and Tashiro (2004) backcrossed *A. fistulosum*, possessing cytoplasm of *A. galanthum* with male fertile lines of cultivar 'Kujyo' and observed that obtained lines drew equal level of seed productivity to that of cultivar (control). The study demonstrated that cytoplasm of *A. galanthum* might be useful for producing commercial F_1 seeds of *A. fistulosum*. A study of interspecific hybridisation between *A. cepa* and *A. ampeloprasum* was conducted by Peterka *et al*., (1997) with a purpose of obtaining F_1 hybrids having S-cytoplasm from onion. But, *A. cepa* × *ampeloprasum* hybrid plants resulted in slight pollen viability which might be due to irregular meiotic chromosomal pairing of parental genomes.

Disease resistance

Since time immemorial, *A. roylei*, *A. galanthum*, *A. fistulosum* are used to introgress resistance to several pests and diseases into cultivated *Allium cepa* (onion). Among all the edible Alliums, *Allium cepa* is the economically important species which is consumed and grown worldwide [Bal *et al*., 2019(a); Bal *et al*., 2019(b); Bal *et al*., 2020(a); Bal *et al*., 2020(b); Bal *et al*., 2021; Bal *et al*., 2022]. So in order to broaden genetic variation in *Allium cepa* it has to be crossed with other species within the genus *Allium* especially with *A. fistulosum* which harbours resistance genes against anthracnose (*Colletotrichum gloeosporioides*), leaf blight (*Botrytis squamosa*), onion yellow-dwarf virus (OYDV), onion fly (*Delia antiqua*), onion smut (*Urocystis cepulae*), pink root (*Phoma terrestris*). First interspecific hybridisation between *A. cepa* and *A. fistulosum* was attempted in 1931, upon which, out of hundred hand pollinations, only seven seeds were secured, leaving only one seedling survived. The hybridisation was repeated in 1933, securing 110 seeds from which only 25 interspecific hybrids were obtained. After over 70 years, anew, several researchers reported genic-cytoplasmic incompatibility, stylar incongruity and central cell genic-cytoplasmic incongruity existed between onion and *A. fistulosum* validating hybrid sterility. To address such crossing barriers Khrustaleva and Kik (1998, 2000) suggested abridging *A. roylei* (2n=2x=16) in order to ease in transferring genes from *A. fistulosum* to onion (*A. cepa*). *A. roylei* has an intermediate amount of DNA (28.5 pg/2C) as compared to both which allows it cross well with both *A. cepa* and *A. fistulosum*. Bridge-cross populations of first and second generations from *A. cepa*, *A. fistulosum* and *A. roylei* were recognised as fertile and thus desirable horticultural traits along with disease resistance can be introgressed successfully into the genome of cultivated onions (*Allium cepa*). Other than *A. roylei* and *A. fistulosum*, *A. galanthum* is reported to transfer anthracnose disease (*Colletotrichum gloeosporioides*) resistance to cultivated onion (*Allium cepa*) (Khrustaleva and Kik, 2000) by screening onion bulbs and its wild relatives in order to identify potential sources of resistance to the disease. Inference of such investigation laid out the facts that highest level of resistance was observed in accessions in *A. fistulosum* and *A. galanthum*, while partial resistance to *C. gloeosporioides* was observed in *A. roylei* followed by *A. pskemense* and *A. altaicum*. Furthermore, to all examined isolates of this pathogen, the screened accessions of *A. oschaninii* and *A. cepa* were reported to be susceptible. Successful crosses between leek (*Allium porrum* L.) and Kurrat (*Allium ampeloprasum* var. *kurrat*) were made by several researchers; hybrids obtained from such crosses were backcrossed to leek in order to introgress yellow strip virus resistance to *A. porrum*.

Metabolites and odour compounds

Interspecific hybridization between species is useful in improving taste and odour of edible Alliums. Breeders find introgression of S-containing compounds and flavonoids into edible Alliums important as it would not only enrich metabolites and flavonoid content in the crop itself but would also add wholesomeness to human diet. Hybridisation conducted between onion (*A. cepa*) and garlic (*A. sativum*) by several researchers with an aim to produce hybrids possessing not only *S*-propenyl-L-cysteine-sulfoxide (major flavour inducing factor in *A. cepa*) but also alliin (chemically which is *S*-allyl-L-cysteine-sulfoxide, a flavour inducing factor in *A. sativum*) and the results of such experiment revealed that leaves (alongside bulbs) of the hybrids produced flavour precursors. Besides, hybrids obtained from *A. fistulosum* × *A. macrostemon* possessed sulphur compounds identified neither in *A. fistulosum* nor in any other *Allium* species.

CONCLUSION

Interspecific hybridisation within genus *Allium* is a pre-eminent method in providing new gene pool alongside uplifting genetic variation. The mechanism is considered to be fast and one of the most useful way of increasing both quality and quantity of crop yield. Such hybridisation techniques not only eliminates obligation of applying pesticides by providing complete or partial resistance to cultivars but also helps to introgress wild characters, useful odour compounds and metabolites into edible *Allium* species adding wholesomeness to human diet.

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