BUCKWHEAT BREEDING. PAST, PRESENT AND FUTURE

ŽLAHTNJENJE AJDE V PRETEKLOSTI, SEDANJOSTI IN PRIHODNOSTI

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ABSTRACT

Buckwheat Breeding. Past, Present and Future.

Buckwheat crop improvement by breeding has been taking place over the past 100 years or more. During this time there has been improvements in many desirable agronomic characteristics which has resulted in higher yields in many of the breeding programs. Phenotypic modifications, such as dwarf, semi-dwarf and branching have been reported. There has also been an effort to increase flower number as this has been shown in cross pollinating buckwheat, to increase yields. Flower cluster modifications and their effects on yield have also been studied. Increased reports on the discovery of buckwheat wild species have been reported from several programs with many interspecific crosses having taken place. Several of these crosses were performed with *Fagopyrum esculentum* in efforts to increase variability which can be used to increase yield potential as well as to obtain increased nutritional components. More recent efforts have focused on the development of self-pollinating buckwheat, both from introgression of genes from *Fagopyrum homotropicum* as well as from mutations in cross pollinating buckwheat. The main problem has been in breeding depression which has occurred in many of the reported attempts. However, high yielding homomorphic, self-pollinating varieties have been developed and are now in commercial production. There is now emphasis being placed on many of the nutritional aspects of buckwheat flour as well as value added components. It is expected that this will increase over time.

Key words: Buckwheat breeding, homomorphic, autogamous buckwheat.

IZVLEČEK

Žlahtnjenje ajde v preteklosti, sedanjosti in prihodnosti

Žlahtnjenje ajde poteka že več kot 100 let. V tem času je bila dosežena izboljšava željenih agronomskih lastnosti, kar je pri mnogih programih žlahtnjenja omogočilo večje pridelke. Raziskovalci poročajo o fenotipskih modifikacijah, kot je pritlikava ali pol-pritlikava rast in razvejanje. Za povečanje pridelka so bile raziskane modifikacije socvetij. Število poročil o odkritjih divjih sorodnikov ajde in o mnogih medvrstnih križanjih se je v zadnjem času povečalo. V mnoga od teh križanj je bila vključena navadna ajda (*Fagopyrum esculentum),* da bi povečali variabilnost, kar bi lahko omogočilo povečanje pridelka in izboljšanje prehranskih lastnosti. Novejša prizadevanja so se osredotočila na razvoj samooplodnosti pri ajdi, z vključitvijo genov vrste *Fagopyrum homotropicum,* kot tudi mutacij pri ajdi, ki se je opraševala navzkrižno. Pri tem je bila glavna težava preseči depresijo zaradi samooploditev, depresija se je pojavila pri večih poskusih samooploditve. Ne glede na to je uspelo dobiti visokorodne homomorfne samooplodne sorte za ponudbo na trgu semen. Sedaj se prizadevanja usmerjajo k izboljšanju prehranske vrednosti ajde in pomembnih sestavin v ajdovi moki. Pričakovati je, da se bo pomen prehranske vrednosti ajde sčasoma še povečeval.

Ključne besede: žlahtnjenje ajde, homomorfnost, samooplodna ajda

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INTRODUCTION

Buckwheat (*Fagopyrum esculentum*) crop improvement has been ongoing for a very long time. It is a very nutritious crop and fits well into crop rotations. However, due to its heteromorphic sporophytic crossing system it has been a difficult species for plant breeders to make rapid progress. This has resulted in many other crops obtaining much higher yields and increased nutritional characteristics at a much faster rate that buckwheat. Therefore, there are many reports of countries and areas that have seen decreased production of buckwheat over the past century with marginal production now being the norm in many areas.

Buckwheat crop improvement programs have produced many new varieties with increases in yield or with other increased beneficial nutritional properties. However, when looked at from a commercial outlook there has been little change in yield from these efforts. Perhaps this is due to there being only a few buckwheat breeding programs world-wide focusing only on buckwheat. Many of the present breeding efforts are combined with breeding on other crops and therefore have limited ability to make major improvements. Buckwheat crop improvement must therefore become more coordinated in order that crop improvement objectives can be realized.

PAST BUCKWHEAT BREEDING EFFORTS

Due to *Fagopyrum esculentum* having a heteromorphic, sporophytic incompatibility system initial crop improvement methods were achieved by selection. However, this was maternal selection only as the pollen parent was unknown. Pollinations between individual plants or lines was severely restricted as all crossing parents and the resulting progeny had to have spatial or caged isolation from other buckwheat. Thus the breeding programs could only make limited improvements as compared to those made with rice, wheat or maize.

Early studies have produced homomorphic self-fertile plants (Marshall 1969, Fesenko & Lokhatova 1981) by probable mutations. However, in many cases these also had severe inbreeding depression from possible recessive mutations that could survive in cross-pollinating lines. There have been exceptions to this as the author found one line that was homomorphic with short anthers and pistils and that had no inbreeding depression after several generations.

There has been a lot of recent interest in attempting interspecific crosses, especially after the finding and reporting of new buckwheat species (Ohnishi 1991, 1998a, 1998b, Chen 2016). The finding and identification of these wild species of *Fagopyrum* has triggered, not only a lot of interest in studying the possible interspecific crosses that can be possible, but has also resulted in the development of essential methodology required in the making of the crosses, such as embryo rescue techniques or hot water emasculation. Although reports of successful crosses that have been made (Wang & Campbell 1998, Chen 2016) have created a great deal of interest in this area, many of the interspecific hybrids have been found to be sterile. The major exception to this has been the cross of *Fagopyrum esculentum* by *Fagopyrum homotropicum* (Campbell 1995). This cross has paved the way to successful introgression of the self-compatible character into common buckwheat.

Nutritional aspects of buckwheat has also received interest in the past. Increasing the rutin content has been the focus of some breeding programs and buckwheat germplasm collections have been screened and high rutin accessions have been identified. Certainly buckwheat has long been viewed as having other desirable nutraceutical properties and these have also received attention.

PRESENT BUCKWHEAT BREEDING EFFORTS

Buckwheat breeding programs at the present time are almost all focused on cross-pollinating common buckwheat. Although Tartary buckwheat has received limited interest, especially in easy dehulling types, there has not been a concerted effort on this crop. Much of the common buckwheat in the large area of India, China, Nepal and Bhutan is mainly grown in high, arid regions in the mountains. It is grown as a subsistence crop and as such is an essential part of the diet for these people, however, these

areas do not appear to get the notice or support required to better support their needs. Most of the buckwheat grown are local land races that have received selection from the growers although there are some varieties available that have been developed by public institutions.

Buckwheat germplasm efforts have received attention in several countries around the world. Many of these have been characterized and evaluated for qualitative and quantitative traits so that they are now available for utilization in buckwheat improvement programs. However, there is an increasing loss of genetic variability in many areas and this has become a critical issue (Rana, Singh & Yadav 2016).

Efforts in yield improvement in cross-pollinating common buckwheat have been mainly centered on flower number, cluster number, branching habit, plant habit, leaf size and shape, days to maturity and percentage seed set. As the percentage seed set in buckwheat is very low, usually in the range of 11 to 12 percent of flowers produced, this has resulted in plants with more flowers in order to increase yield. The high abortion rate has been the major obstacle of obtaining higher yielding cultivars.

FUTURE BUCKWHEAT BREEDING EFFORTS

Buckwheat breeding efforts, despite the consumption and varied uses of this crop, sadly lacks a major, coordinated effort. It appears that the most interest in past buckwheat breeding programs has been on the commercial aspects of the crop. Although this is a very valid reason for these efforts, the needs of the poor growers that utilize this essential crop for their subsistence has been sadly neglected. Most of the agronomic studies have been conducted to increase yields or nutritional aspects of the crop in high input agricultural management systems and there is a dearth of information on production aspects of this crop under subsistence farming practices which growers in these areas.

As common buckwheat has a very high abortion rate, of almost 88% of flowers produced, this is one of the major concerns which must be addressed in order for higher yielding cultivars to be developed, which can compete better with other crops for grower acceptance. The production of such a high percentage of flowers that do not contribute to yield but require a very large input from the plants will require coordinated efforts to overcome. Unfortunately, the finding of plants/lines that have a much lower flower number but still achieve high yields is extremely difficult. But as a doubling of yield should only require about 25% of the flowers now being produced then the inputs the plant is now putting into the 75% of the flowers which do not contribute to yield could be diverted into seed production. As there is a great deal of variability in cluster shape and number, as well as in flower number, that has been found in self-pollinating buckwheat perhaps this is where the most future efforts should be expended (Figs. 1 – 17).

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Fig. 1: Field of self pollinating buckwheat
Slika 1: Polje s samooplodno ajdo

Fig. 2: Leaf sizes
Slika 2: Velikosti listov

Fig. 3: Plant habit of Kiku types
Slika 3: Kiku oblika rastlin

Fig. 4: Kiku branching habit
Slika 4: Razvejanje pri rastlinah Kiku

Fig. 5: Kiku has very short internodes at first
Slika 5: Na začetku rasti so internodiji zelo kratki

Fig. 6: Early Kiku growth
Slika 6: Začetek rasti pri Kiku

Fig. 7: Early ground cover by Kiku
Slika 7: Rastline Kiku hitro pokrijejo tla

Fig. 8: Plant with early 'weed control' leaves
Slika 8: Rastlina z obliko listov, ki zgodaj zasenčijo rast plevelov

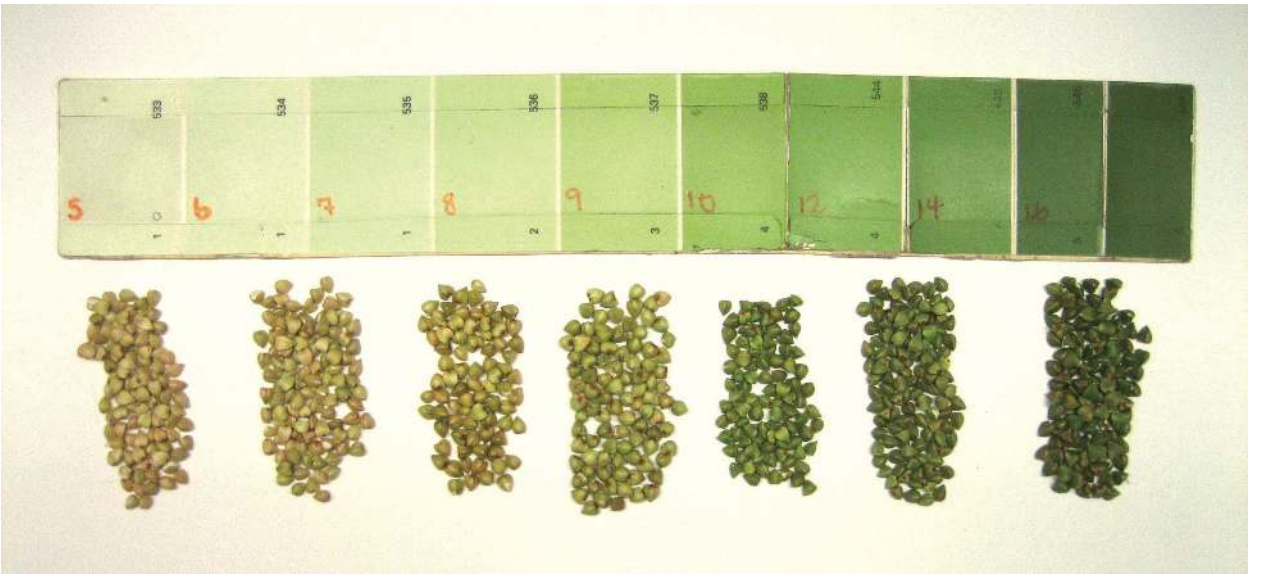

Fig. 9: Enhanced green testa types
Slika 9: Različne stopnje zelenega obarvanja teste

Fig. 10: Flower cluster types that have been found in common buckwheat
Slika 10: Različne oblike socvetij ki smo jih ugotovili pri ajdi

Fig. 11: Enhanced flower clusters
Slika 11: Povečano število socvetij

Fig. 12: Enhanced flower cluster plants
Slika 12: Rastline z obogatenimi socvetji

Fig. 13: Differing auxillary flower cluster types
Slika 13: Različni tipi stranskih socvetij

Fig. 14: Determinant flower clusters
Slika 14: Socvetja ajde s končno rastjo

Fig. 15: Ball cluster
Slika 15: Kroglasto socvetje

Fig. 16: Plant with ballclusters
Slika 16: Rastlina s kroglastimi socvetji

Fig. 17: Red pericarp
Slika 17: Rastlina z rdečim perikarpom