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Research Article

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Cowpea (*Vigna unguiculata* (L.) Walp.) Agronomic Traits Needed in Tropical Zone

Justin Abadassi*

Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, 03 BP 2547 Cotonou, Bénin

*Corresponding Author E-mail: jabadassi@gmail.com

ABSTRACT

Cowpea agronomic traits needed by producers and consumers should be considered in the breeding programmes. They vary with the target zone. Among those indicated in tropical zone appear: earliness, erect growth habit, resistance to the enemies (insect pests, pathogens, weeds), drought tolerance, high and stable seed yield, high harvest index, and appropriate seed quality. The importance, the inheritance, the heritability, and the possibility of improvement of those traits are reviewed. The research results reported indicate that some of the traits are monogenic or oligogenic whereas others are polygenic. Dissimilarities in the results, probably due to the materials and the methods used, have been noted for some traits . Heritability estimates reported are low, moderate or high depending on trait, population, environment, and computation method. Breeding for the traits considered can be successful if adequate methods are used.

Key words*: agronomic traits, breeding, cowpea, genetics, tropical zone.*

INTRODUCTION

Cowpea *(Vigna unguiculata* (L.) Walp.) is a legume mainly grown in tropical and subtropical regions in the world for vegetable and grains and to lesser extent as a fodder crop[61]. It serves also as cover crop and improves soil fertility by fixing atmospheric nitrogen[67]. Cowpea is one of the important food legumes in the hot-dry tropics and subtropics and especially in sub-Saharan Africa (SSA)[76]. It is indigenous to SSA[24] and a food security crop in the semi-arid zone of West and Central Africa[7]. Rich in proteins (19 to 35% of dry weight[38]), it contributes to satisfy the food needs of several people in the developing countries.

Cowpea yields remain low (less than 1 t/ha) in a lot of producing areas due mainly to technical constraints (deficiencies of the varieties, low soil fertility, inappropriate farming techniques), biological constraints (pests, diseases, weeds, birds, rodents), socio-economic constraints (lack of credit and/or labor), and climatic constraints (insufficient and badly distributed rainfall). Several potentially high yielding varieties have been created by international and national agricultural research centers; but they were not always adopted by producers and consumers due to deficiencies such as susceptibility to insect pests and diseases and inappropriate grain quality. The breeding programmes should, therefore, pay attention to the traits needed by the producers and the consumers of the target area. This paper presents the agronomic traits usually needed in cowpea in tropical zone and reviews their importance, inheritance, heritability, and possibility of improvement.

Earliness

Earliness in cowpea refers to flowering (appearance of open flowers) or maturity (pods drying). It is usually expressed in days after planting. But, such an expression complicates ranging in earliness groups when a variety is cultivated in different ecologies. The use of thermal units, as indicated Bonhomme *et al.*[22], permits to avoid that problem.

Alidu *et al.*[11] reported a negative significant correlation between days to flowering and seed yield. Similarly, Kamai *et al.*[40] found that days to first and 50% flowering and days to physiological maturity were negatively correlated with cowpea seed yield. Oladejo *et al.*[57] reported a close correlation between days to 50% flowering and days to 50% pod formation.

Early maturity is an important agronomic trait for the adaptation of annual crops including cowpea to any agroecological zone[17]. In arid and semi-arid regions, short cycle duration cowpeas which mature from 55 to 60 days are ideal for the short growing season[5]. In more humid areas with bimodal rainfall, early maturing varieties are also needed for the short rainy season. Early cultivars can escape drought and some insect infestations, provide the first food grain and marketable product and be grown in a diverse array of cropping systems[81].

Adeyanju and Ishiyaku[6] found that earliness in cowpea was under polygenic control and highly heritable (narrow sense heritability estimate = 0.91). Padi and Ehlers[62] reported also high narrow sense heritability estimates for earliness (days to flowering). According to Ayo-Vaughan *et al.*[17], days to flowering is influenced by additive gene effects and days to maturity by additive-dominance gene actions. The same authors reported low narrow sense heritability estimates (less than 0.20) for the two earliness variables. Alidu *et al.*[11] found also a low narrow sense heritability estimate (0.14) for days to flowering. The populations studied, the environment and the computation methods may explain the discordance noted in the heritability estimates.

High narrow sense heritability estimates were obtained for earliness in some cowpea populations. Selection for that trait can, therefore, be effective. Several international and national agricultural research centers obtained good results in that field. The International Institute of Tropical Agriculture (IITA), for example, developed and released many high-yielding early maturing cowpea cultivars in several African countries during the last three decades.

Growth habit

The major cowpea growth habits are: erect, semi-erect, prostrate, and climbing. Most cowpea plants are indeterminate in growth habit; however some of the newly developed early maturing varieties have a determinate growth phenotype[83].

Erect growth habit facilitates farming operations such as weeding, insecticide application, and harvest. It is needed for mechanization. A prostrate growth habit may contribute to weed control in ensuring ground covering. But, Wang *et al.*[87] found that erect cowpea growth habit may be generally more competitive with weeds than semi-erect or prostrate growth habit. Moreover, prostrate growth habit complicates some farming operations and increases pods vulnerability[1].

Uguru and Uzo[85] studied three types of growth habit (decumbent, climbing and bushy) and found that two allelic pairs of genes condition growth habit. But, according to Matos Filho *et al.*[50], Ribeiro *et al.*[70] and Lackyan and Dalvi[44], growth habit is monogenic. The materials used and the types of growth habit considered may explain the differences noted. Fery and Singh[34] reported broad sense heritability estimates for growth habit traits such as plant height, branch number, node number, stem diameter, leaf number, leaf area, and root length ranging from 0 to 0.98. Selection for some growth habit traits may, therefore, be effective in some cowpea populations.

Resistance to enemies

The most important cowpea biological enemies include insect pests, pathogens, and weeds.

Insect pests and diseases are the most important impediments to cowpea production[88]. A complex of insect pests attack the crop from vegetative stage to storage. They include pre-flowering pests (leafhoppers (*Empoasca* sp.), aphids (*Aphis craccivora*), foliage beetles (*Ootheca* sp.)), post-flowering pests (flower thrips (*Megalurothrips sjostedti*), pod borers (*Maruca* sp., *Cydia* sp.), flower beetles (*Mylabris* sp.), pod sucking bugs (*Anoplocnemis curvipes*, *Riptortus* sp., *Acanthomia* sp.)) and storage pests (storage weevils (*Callosobruchus maculatus*, *Bruchidius atrolineatus*)). Those pests cause important yield and grain losses in cowpea[82,31,88,61].

The most important cowpea diseases occurring in tropical zone have been listed and described by Singh and Allen[82]. Among them appear fungal diseases (seedling mortality, stem rots (anthracnose, *Pythium* stem rot, *Sclerotium* stem rot), wilts (*Fusarium wilt*), leaf diseases (*Cercospora* leaf spot, *Septoria* leaf

spot, web blight, *Ascochyta* blight, brown rust, black spot or leaf smut, powdery mildiou), pod diseases (brown blotch, scab)), bacterial diseases (bacterial blight, bacterial pustule or bacterial spot) and virus diseases (cowpea severe mosaic, cowpea yellow mosaic, cowpea aphid-borne mosaic, cowpea golden mosaic). Some of them can cause yield losses of up to 100%[82].

A lot of weeds cause significant damages to cowpea plants in tropical zone. They include Euphorbiaceae such as *Euphorbia heterophylla* or *Euphorbia hirta*, Cyperaceae like *Cyperus* sp., Gramineae such as *Imperata cylindrica*, *Panicum maximum* or *Digitaria velutina*, and Scrofulariaceae like the parasite *Striga gesnerioides*. Yield losses of up to 86%, due to weeds, have been noted[46].

Although other control means exist for some enemies, the use of resistant varieties appears as the most economical, practical, and ecological enemy control measure. Resistance to insect pests, diseases, and weeds is, then, highly needed in cowpea varieties. Several authors including Bliss and Robertson[21], Fery *et al.*[35], Patel *et al.*[63], Fatunla and Badaru[33], Redden[69], Prakash and Shivashankar[66], Adjadi *et al.*[8], Abadassi *et al.*[3], Bata *et al.*[19], Bosquez-Perez *et al.*[23], Bruening *et al.*[25], Hobbs *et al.*[36], Melton *et al.*[51], Ombakho *et al.*[58], Rigert and Foster[71], Rusoke and Fatunla[72], Pathak[64], Ponz *et al.*[65], Bateman *et al.*[20], Singh and Emechebe[77], Ouatara and Chambliss[60], Atokple *et al.*[15], Chen and Heath[26], Singh *et al.*[79], Atokple *et al.*[16], Ryerson and Heath[73], Arshad *et al.*[13], and Tumwegamire *et al.*[84], studied the genetics of resistance to cowpea enemies. In most of the cases, resistance is monogenic or oligogenic (one to three genes are involved). It is also at least moderately heritable in many cases. Thus, it may be possible to incorporate resistance to enemies into interesting varieties using appropriate methods. Major gene resistances are theoretically unstable. But, experience has shown that they can be effective for several decades. However, stability is better achieved through the development of horizontal resistance. International agricultural research centers like IITA and national agricultural research institutions work to develop cowpea cultivars combining resistance to the major insect pests, diseases, and weeds prevailing in tropical zone and obtained appreciable results.

Drought tolerance

The mechanisms used by plants to cope with drought stress can be grouped into three categories: drought escape, drought avoidance, and drought tolerance[54]. Ashley[14] defined drought tolerance as the ability of plants to live, grow, and yield satisfactorily with limited soil water supply or under periodic water deficiencies. In cowpea, water deficit reduces leaf area index, chlorophyll content, number of pods per plant, and seed yield[18,27,11].

Two approaches are usually used to screen for drought tolerance in plants:

- The empirical or performance approach which utilizes seed yield and its components as the main criteria
- The analytical or physiological approach which uses a specific morphological or physiological trait associated with drought tolerance.

Agbicodo *et al.*[9] listed, on the basis of the findings, the following methods as the most suitable for screening large numbers of cowpea lines for drought tolerance: determination of chlorophyll fluorescence, stomata conductance measurements, abscisic acid (ABA) measurements, measuring free proline levels, wooden box screening (for drought tolerance at seedling stage), and delayed leaf senescence (DLS). Verbree *et al.*[86] found that trifoliate necrosis was the most reliable indicator of overall shoot drought tolerance in cowpea seedlings. A close correspondence was noted between drought tolerance at seedling and reproductive stages[80,9].

Drought is an important cowpea production constraint especially in the semi-arid regions. It is the major abiotic constraint of cowpea production in West and Central Africa[9]. The use of drought tolerant varieties is, therefore, essential for increased and sustainable cowpea production. Mai-Kodomi *et al.*[48] reported that drought tolerance in cowpea was governed by a single dominant gene. It may be then possible to incorporate that trait into elite cowpea lines.

Seed yield

Seed yield in cowpea is the product of components including the number of pods per plant, the number of seeds per pod, and the mean seed weight. Its heritability is low[62,11].

The mean number of pods per plant is the ratio of the number of pods harvested to the number of plants harvested. It is positively correlated with seed yield[10,11,55,53]. Siddique and Gupta[75] showed that additive

gene effects were important in the genetic control of number of pods per plant; but Sharma *et al.*[74] indicated that non-additive gene action was predominant. Ajibade and Morakinyo[10] and Omoigui *et al.*[59] reported low broad sense heritability estimates for the trait (0.20 for Ajibade and Morakinyo (2000) and 0.19 for Omoigui *et al.* (2006)). However, Millawithanachchi *et al.*[53] obtained high narrow sense heritability estimates (0.61 to 0.88) in some crosses. The number of seeds per pod is obtained by counting. According to Ajibade and Morakinyo[10] and N'gbesso *et al.*[55], it is significantly and positively correlated with seed yield; but, Alidu *et al.*[11] found that the two traits were not significantly correlated. The number of seeds per pod is moderately or highly heritable (narrow sense heritability estimates ranging from 0.41 to 0.70[11,53]). The mean seed weight is determined after counting and weighing of a number of grains. It is, according to Ajibade and Morakinyo[10], positively correlated with seed yield; at the opposite, Alidu *et al.*[11] and N'gbesso *et al.*[55] did not find any significant correlation between the two traits. Lopes *et al.*[47] found that seed weight was governed by five genes. The trait may be highly heritable (narrow sense heritability estimate of 0.60 [47] or 0.71[11]).

High and stable seed yielding cultivars are needed in all cowpea producing areas. The data summarized earlier show that number of pods per plant, number of seeds per pod and seed weight may be highly heritable in cowpea. Selection for those traits can, therefore, be effective. The three traits are significantly correlated with seed yield in some cases. It may be then possible to increase seed yield in selecting for number of pods per plant, number of seeds per pod or seed weight. Direct selection for seed yield may also be effective if appropriate methods are used.

Harvest index

Harvest index is the ratio of grain yield to total biomass yield[28]. It is, in cowpea, correlated with seed yield[41,40] and its genetic control involves dominance effects[4]. The heritability of that trait may be low or moderate (narrow sense heritability estimate of 0.17[4]; broad sense heritability estimates ranging from 0.20 to 0.67[39,12,52]).

In several tropical countries, cowpea is cultivated mainly for grains. Varieties with high harvest index are then needed to ensure physiological efficiency especially in the semi-arid regions. Such cultivars can be obtained using adequate methods.

Seed quality

In cowpea, seed quality traits include seed size, seed coat colour, seed coat texture, and cooking time. Cowpea seed size ranges from small to big. For Drabo *et al.*[30], that trait is polygenic and additive gene effects are predominant in its control. However, Ogunbodede and Fatunla[56] proposed a digenic epistatic model for seed size. Karkannavar et al. (1991)[42] identified a dominant gene that conditions big seed. Seed size may be highly heritable[30,62] .

Cowpea seed coat colour varies with variety. The common colours known include: white, brown, cream, green, red, buff, and black. Drabo *et al.*[29] found that seed coat colour was controlled by five genes whereas Egbadzor *et al.*[32] reported that several genes may govern the trait.

Four seed coat textures are usually distinguished in cowpea: smooth, rough, wrinkle, and loose. Kehinde and Ayo-Vaughan[43], Singh and Ishiyaku[78], and Mashi[49] indicated that two pairs of genes govern seed coat texture in cowpea.

Cooking time ranges from short to long. Mashi[49] found that two genes control cooking time in the varieties he studied. He also reported high narrow sense heritability estimates (0.58 to 0.85) for that trait.

Seed quality is very important for consumers. All the consumers prefer short cooking time varieties to save time and energy. The other seed quality characteristics needed in tropical zone depend on the region and the destination of the grains. For example, cowpea varieties with large white or brown grains and rough seed coat are generally preferred throughout West Africa whereas varieties with medium brown or red grains and smooth seed coat are preferred in East Africa[45,49,37]. Selection for seed quality in cowpea may be efficient; but, to be satisfactory, it should, as indicated Abadassi[2], concern a few traits highly heritable, positively correlated and not negatively correlated with other important agronomic traits.

CONCLUSION

Cowpea agronomic traits needed by producers and consumers in tropical zone vary with the target area. However, some of them always appear. They include: earliness, erect growth habit, resistance to the

enemies (insect pests, pathogens, weeds), drought tolerance, high and stable seed yield, high harvest index, and appropriate seed quality. The research results reported indicate that some of the traits are monogenic or oligogenic whereas others are polygenic. Dissimilarities in the results, probably due to the materials and the methods used, have been noted for some traits. Heritability estimates reported are low, moderate or high depending on trait, population, environment, and computation method. Breeding for the traits considered can be successful if adequate methods are used.

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