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# RESTRUCTURING COWPEA FOR HIGHER YIELD*

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## ABSTRACT

**The cowpea breeding programmes are reviewed and achievements at two major centres of cowpea research, i.e. IITA (Nigeria) and IARI (India), are summarized. Early and extra early genotypes are always photoperiod-insensitive, medium maturity varieties could be sensitive or neutral to day length, while late varieties are always highly sensitive to photoperiod. It has been demonstrated that with the availability of short or medium duration varieties having erect plant type and resistant to major diseases, stable yields in the range of 25–30 q/ha can be obtained under appropriate crop management. Even early maturing varieties have yielded up to 29.88 q/ha in isolated trials. Breeding for insect resistance continues to be an uncertain area, while varieties resistant to major viral, bacterial and fungal diseases have been developed. Photoperiod-neutral varieties (which are also early maturing) possess wider adaptability. It has been demonstrated that high grain yield can be combined with high harvest index in the early and extra-early varieties, maturing in 60–65 days. The future varieties of cowpea should combine high yields with upright growth habit, bushy plant type, determinate flowering, early-medium maturity, and long peduncles keeping the pods above the plant canopy. Attempts are in progress to evolve varieties which can tolerate shady conditions of mixed cropping with tall cereals like maize, sorghum and pearl millet, as well as varieties for dual (grain-fodder, grain-vegetable) purpose.**

**Key words:** Cowpea, *Vigna unguiculata*, stable yields, ideal plant type.

Cowpea (*Vigna unguiculata* (L.) Walp.) is an important food legume in the tropics and subtropics of Asia, Africa, Central and South America, and parts of southern Europe and United States of America [1–5]. It occupies an area of 9 million ha in the world [6] with a total production of more than 2.5 million tonnes of dry grain. The major cowpea growing countries in Asia are India, Sri Lanka, Bangladesh, Myanmar, China, Korea, Thailand,

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Indonesia, Nepal, Pakistan, Philippines and Malaysia, where it is grown over about 1.2 million ha [1]. India alone contributes 0.5 million ha to its area. Cowpea is the major source of dietary protein in sub-Saharan Africa, where it originated [7] and presently forms an integral part of traditional intercropping systems with millet and sorghum in the savannas of northern Guinea and Sudan, and the Sahelian region of Central and West Africa as well as the coastal savanna and semiarid regions of East and Southern Africa. It is consumed in many forms. In Africa, its tender leaves, immature pods, immature seeds, and dry grains are used as food, and the haulms are used as fodder [8]. In Asia, its leaves are not used in human food. It is also grown for green fodder and green manure. Out of the world total of about 9 million ha, Africa alone accounts for about 6 million ha. However, the average yield of cowpea is very low, particularly in Africa, due to numerous biotic and abiotic constraints such as diseases, insect pests, drought and low fertility, as well as low yield potential of the traditional cowpea varieties. Most of the local varieties are late maturing with indeterminate and spreading growth habit. Also, the land races grown in West and Central Africa are photoperiod-sensitive, especially selected to fit in the intercropping and relay cropping systems with cereals. Consequently, they have low yield potential and do not respond to better management practices. Sporadic research efforts have been in progress in several countries [3] but cowpea improvement received a great deal of attention world wide from 1970 onwards when the International Institute of Tropical Agriculture (IITA) initiated systematic breeding programme to develop improved cowpea varieties in collaboration with national programmes.

Cowpea, like other pulses, is grown in marginal lands with little or no inputs and, therefore, the average yield is very low. With the advent of input responsive high yielding varieties of wheat and rice and hybrid varieties of maize and sorghum, cultivation of pulses, in general, has been further marginalized which has led to manifold increase in cereal production as against stagnant or reduced production of pulses causing serious nutritional imbalances in the developing countries. Is it possible to match the 'Green Revolution' in cereals with a similar 'green revolution' in pulses? Considering the fact that all the fertile and irrigated land and most of the available inputs and resources are preferably allocated to cereals, a 'green revolution' in pulses may not be a very easy proposition, unless economic considerations tilt the situation in favour of pulse crops. In fact, this has already happened in the case of chickpea production in India, where high prices in 1993 and 1994 boosted its production, creating surplus, a part of which had to be exported in 1995–96 to protect domestic prices from crashing to uneconomic levels. However, great advances in cowpea production can be made if:

1) extra-early input responsive varieties are developed to fit into the niches of cereal based cropping systems, and

2) disease and insect resistant, medium/long duration varieties with drought tolerance and high nitrogen fixation ability are developed to maximize grain and fodder production in marginal drought prone areas.

Among all the pulses, cowpea has maximum genetic diversity for plant type, growth habit, drought tolerance, maturity and seed type etc. and, therefore, it offers a unique opportunity to cowpea breeders to design and develop specific plant types [9] with higher yield potential to suit different cropping systems and agro-ecological niches.

## THE IDEAL COWPEA VARIETY

In view of the fact that cowpea is cultivated in a wide range of environments as a component of the existing cropping systems either for grain, green leaves, green pods, for fodder, or for both, no single variety can be suitable for all conditions and all purposes. Thus, right from the beginning, IITA scientists recognized the need for developing a range of varieties to suit specific requirements. However, the initial thrust was to develop cowpea varieties for pure crop with erect or semierect growth habit which would respond to good management similar to what had already been achieved in cereals like wheat and rice with dwarfing genes. It was also recognized that a medium or late maturing cowpea variety grown as pure crop may compete with cereals for the same piece of land and, therefore, extra-early maturity varieties should be developed to fit into the niches of cereal-based cropping systems enabling the farmers to intensify agriculture and maximize the land and labour use efficiency. The ideal plant type for pure crop cowpea was conceived as follows:

Erect/semierect plant type with medium sized leaves and basal branches as anchors to avoid lodging, 60–70 days of crop duration with near-synchronous maturity, long peduncles with pods above the plant canopy for easy harvesting by manual or mechanical means as shown in Fig. 1, medium seed size with rough or smooth seed coat to avoid seed quality problem during maturity, harvesting and threshing.

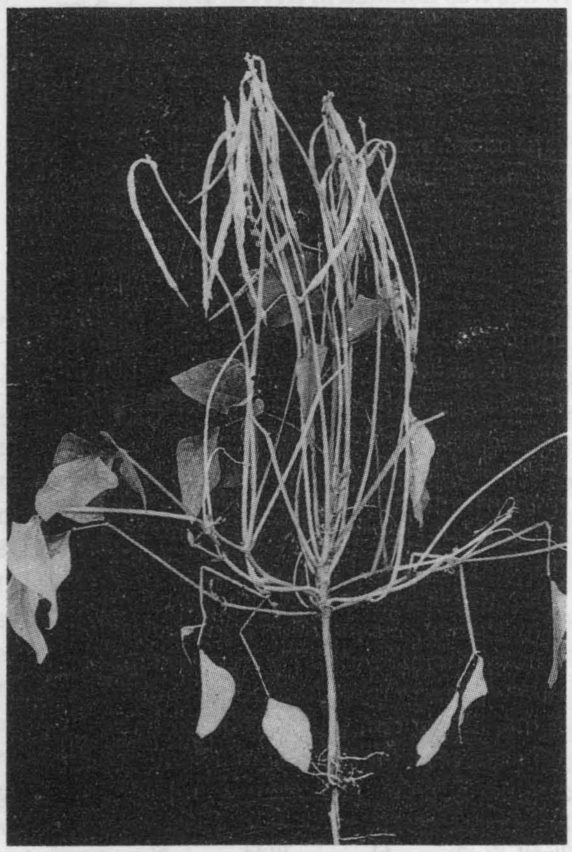

**Fig. 1. IT84E-124, ideal plant type for cowpea. Long peduncles hold pods over canopy and lateral branches at the base provide support against lodging.**

In the Indian context also, emphasis has been mainly on developing varieties with early maturity, compact nontrailing plant type, and resistance to diseases. In recent years, major attention has been focused on evolving varieties with white bold seed.

60-DAY COWPEA VARIETIES

Systematic breeding programme to develop extra-early cowpea varieties was initiated at IITA in 1979 and the first set of improved varieties were collectively called "60-day cowpeas" [10, 11] as they flowered in 30–35 days and matured in 55–69 days after planting. Performance of some of these lines at three locations in Nigeria in the rainy season is presented in Table 1, and performance of extra-early varieties in the dry season on residual moisture in rice fallows in Table 2. The grain yield of extra-early erect varieties ranged from 10–20 q/ha, whereas those of early maturing semierect varieties ranged from 15–30 q/ha, with the harvest index ranging from 40 to 50% compared to about 25% to 30% of local varieties. Varieties like IT82DE-9, maturing in 61 days, with high grain yield (15.49 q/ha) and also high harvest index (52%) are the best as they produce more grain and less foliage. Attempts must be directed to raise the yield level maintaining harvest index around 50%. The variety IT82DE-9 gave highest mean yield (19.98 q/ha) under normal sowing as well (Table 1). This means that the variety was selected for high yield potential combined with early maturity which does not allow the plant to produce excessive foliage. In terms of per day productivity (30–40 kg per

**Table 1. Grain yield of extra-early and early maturing varieties of cowpea at various locations in Nigeria in 1982**

| Variety | Yield at different locations (q/ha) | | | |
|---|---|---|---|---|
| | Ibadan | Mokwa | Samaru | Mean |
| | **Early Maturing Trial 1 (55–65 days, erect)** | | | |
| IT82E-32 | 19.61 | 21.09 | 18.09 | 19.60 |
| IT82E-9 | 20.03 | 20.79 | 16.14 | 19.98 |
| IT82E-56 | 18.10 | 18.75 | 10.49 | 16.01 |
| IT82E-5 | 14.20 | 18.45 | 20.18 | 17.61 |
| IT82E-77 | 12.85 | 15.94 | 15.59 | 14.79 |
| IT82E-60 | 13.74 | 15.63 | 11.27 | 13.55 |
| Location mean | 14.42 | 18.44 | 15.29 | |
| LSD (5%) | 4.28 | 3.07 | 4.44 | |
| CV % | 21 | 14 | 22 | |
| | **Early Maturing Trial 2 (60–69 days, semierect)** | | | |
| IT82E-16 | 30.23 | 21.88 | 16.20 | 22.77 |
| IT82E-18 | 24.44 | 23.91 | 18.93 | 22.43 |
| IT82E-25 | 20.16 | 27.19 | 17.81 | 21.72 |
| IT82E-3 | 22.07 | 21.41 | 14.47 | 19.32 |
| IT82E-12 | 19.72 | 22.81 | 17.06 | 19.86 |
| IT82E-17 | 20.42 | 20.47 | 16.56 | 19.15 |
| Location mean | 22.84 | 22.94 | 16.83 | |
| LSD (5%) | 5.31 | 4.93 | 3.6 | |
| CV % | 31 | 17 | 16 | |

**Table 2. Performance of extra-early cowpea varieties in rice fallow on residual moisture at Ibadan in 1984–85**

| Variety | Days to maturity | Yield (q/ha) | Harvest index (%) |
|---|---|---|---|
| IT83D-442 | 56 | 15.70 | 46 |
| IT82DE-9 | 61 | 15.49 | 52 |
| IT82D-889 | 56 | 13.41 | 50 |
| IT82E-124 | 60 | 13.68 | 47 |
| IT82E-60 | 61 | 10.43 | 51 |
| LSD 5% | 0.7 | 0.23 | 9 |

*Planted November 30, 1984.

day), these yields compare very well with the best yield levels in cereals. Since cowpea is a nitrogen fixing legume crop, the only input given to these trials were about 30 kg $P_2O_5$/ha, 30 kg $K_2O$/ha, and about 2–3 sprays of insecticides to protect against major insect pests. These varieties along with others were multiplied and distributed to over 60 national programmes in 1984, and the yield data were received from 50 locations. The mean yield over all varieties (location mean) was less than 10 q/ha at 18 locations, between 10–15 q/ha at 19 locations, between 15–20 q/ha at 7 locations, and between 20–25 q/ha at 6 locations. The yield of individual varieties ranged from 3–32 q/ha. Such wide range in performance could be due to several reasons, especially if insecticide was not applied on time or not applied at all. The mean performance of 7 varieties at 11 locations where the trials were well managed is presented in Table 3 along with that of the local varieties used as check. The experimental varieties, taken together, yielded nearly 39% more grain (19.44 q/ha) in this global trial as compared to the best local check varieties of different countries (pooled average 13.99 q/ha). IT82E-16, IT82E-18 and IT82E-32 did consistently well over all locations with mean yield above 20 q/ha, but other varieties also averaged about 15 q/ha. Interestingly, highest mean yields (23–24 q/ha) were reported from Benin in this trial

**Table 3. Grain yield of early maturing cowpea varieties in different countries in 1984**

| Variety | Yield at different locations (q/ha) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sanguere Cameroon | Kwadoso Ghana | Kumasi Ghana | Yundum Gambia | Ilonga Tanzania | Ibadan Nigeria | Sekou Benin | Abomey Benin | Davie Togo | Konkoen Thailand | Santacruz Venezuela | general mean |
| IT82E-16 | 23.56 | 20.51 | 17.03 | 24.79 | 17.09 | 25.18 | 24.06 | 26.00 | 24.27 | 28.24 | 21.36 | 22.92 |
| IT82E-18 | 32.25 | 22.75 | 15.88 | 21.36 | 14.05 | 18.67 | 25.97 | 29.88 | 19.62 | 24.56 | 23.61 | 22.60 |
| IT82E-32 | 23.88 | 19.50 | 17.66 | 28.57 | 15.13 | 19.17 | 26.09 | 25.06 | 26.10 | 22.38 | 22.43 | 22.36 |
| IT82D-885 | 13.06 | 15.30 | 24.06 | 15.40 | 17.59 | 19.09 | 23.28 | 26.63 | 21.58 | 15.25 | 26.23 | 19.77 |
| IT82D-789 | 18.38 | 19.68 | 14.94 | 16.76 | 13.71 | 19.49 | 24.38 | 20.13 | 20.99 | 18.80 | 19.34 | 18.78 |
| IT82D-889 | 8.25 | 12.44 | 14.63 | 12.53 | 15.31 | 9.54 | 19.94 | 19.00 | 13.26 | 12.50 | 17.36 | 14.07 |
| IT82E-60 | 17.13 | 8.39 | 13.59 | 16.76 | 14.30 | 16.25 | 22.81 | 22.86 | 16.12 | 10.24 | 13.50 | 15.56 |
| Location mean | 19.54 | 16.94 | 16.83 | 19.45 | 15.31 | 18.20 | 23.79 | 24.22 | 20.28 | 18.85 | 20.55 | 19.44 |
| Local check | 10.18 | 5.37 | 10.31 | 20.18 | 11.63 | 15.54 | 22.97 | 15.38 | 15.39 | 6.14 | 20.79 | 13.99 |
| LSD 5% | 5.75 | 3.42 | 4.91 | 5.16 | 3.81 | 4.47 | 3.47 | 6.16 | 5.26 | 5.77 | 4.13 | 4.76 |
| CV % | 21 | 15 | 21 | 18 | 19 | 17 | 17 | 19 | 19 | 24 | 14 | 19 |

spread over nine countries, where the highest yield of 29.88 q/ha was obtained in the variety IT82E-18. This gives a good idea about the yield potential of cowpea. Subsequent tests of the promising varieties at several locations within each country have led to identification and release of some of these varieties for general cultivation (Table 4). Most of the 60-day varieties developed earlier had smooth seed coat and, therefore, not accepted in parts of West Africa. In the Asian countries, seed surface does not influence much its market value. The seed with shining smooth surface may even get higher preference. Therefore, concerted efforts were made to develop early maturing cowpea varieties with a range of seed type acceptable to different regions. The yield performance of these new early maturing varieties ranged from 20–28 q/ha (Table 5). These varieties have been distributed to several national programmes. Thus, a range of early maturing varieties with erect or semierect plant type are now available which yield over 20 q/ha in 60–69 days with minimum inputs but normal crop growth. Also, most of these varieties have relatively high protein content and cook easily compared to the local varieties [12, 13]. These varieties have opened the possibility of successful monocropping in areas with short rainy season, double/triple cropping in rice and/or wheat-based systems, relay cropping in the areas with relatively longer rainy season after millet, sorghum or maize and parallel multiple cropping with cassava, yam and cotton [14–16].

**Table 4. 60-day cowpea varieties released in different countries**

| Country | Varieties released |
|---|---|
| Benin Republic | IT82E-32 |
| Bolivia | IT83D-442, IT82D-889 |
| Botswana | ER-7 |
| Colombia | IT83S-841 |
| Ghana | IT82E-16, IT83S-728-13, IT83S-818 |
| Guinea | IT85F-867-5 |
| Guyana | ER-7 |
| Liberia | IT82D-889 |
| Mozambique | IT82-18 |
| Nepal | IT82D-889, IT82D-752 |
| Nigeria | IT84E-124, IT82E-60, IT82D-716, IT84E-1-108, IT84S-2246-4, IT86D-721, IT86D-719 |
| Philippines | IT82D-889 |
| Sri Lanka | IT82D-789, IT82D-889 |
| Surinam | IT82D-889, IT82D-789 |
| Swaziland | IT82E-18, IT82E-32, IT82E-71 |
| Tanzania | IT82D-889 |
| Thailand | IT82D-889 |
| Uganda | IT82E-60 |
| Yemen | IT82D-789 |
| Zaire | IT82E-18, IT82E-32 |
| Zimbabwe | IT82D-889 |

In India, maximum cultivation of cowpea is concentrated in the arid and semiarid parts of Rajasthan, Gujarat and Karnataka. Early and extra-early varieties with reasonable yields are particularly suited for such conditions with short periods of moisture availability.

BUSH TYPE VEGETABLE COWPEAS

Several countries grow cowpea as a vegetable crop. The most preferred types are the yard-long beans with fleshy tender pods, but these varieties need staking to keep the pods away from the ground to prevent their rotting which involves extra cost and, therefore, restricts the area of cultivation. Bush type vegetable cowpea varieties with 30 cm long succulent pods have been developed which yield up to 180 q/ha green pods with 3–4 pickings beginning 45 days after planting (Table 6). These varieties have semierect plant and extra long peduncles (40–50 cm) protruding well over the canopy, thereby, holding the pods much above the ground (Fig. 2). Picking green pods periodically reduces the load on peduncles and they remain upright all the time. Frequent picking stimulates further flowering and podding on the same peduncles which ensures continuous supply of green pods over 6–7 weeks once picking starts provided soil moisture is not limiting. Seed yield as well as vegetable quality of these varieties are also quite acceptable. These varieties have been distributed to several national programmes.

**Table 5. Performance of the second-generation early maturing varieties at Kano in 1993**

| Variety | Days to maturity | Grain yield (q/ha) | Seed type |
|---|---|---|---|
| IT87D-879-1 | 70 | 28.68 | White, rough |
| IT86D-1010 | 71 | 27.50 | White, black eye |
| IT90K284-2 | 67 | 26.11 | Tan, smooth |
| IT87D-829-5 | 70 | 25.95 | White, rough |
| IT86D-719 | 68 | 23.18 | White, rough |
| IT87D-697-2 | 68 | 22.32 | Brown, rough |
| IT87D-611-3 | 68 | 22.21 | Cream, smooth |
| IT89KD-374-57 | 66 | 19.77 | White, rough |
| IT87D-941-1 | 68 | 19.48 | Brown, rough |
| Dan Ila (local) | 79 | 16.57 | White, rough |
| LSD 5% | 4 | 3.28 | |

**Table 6. Performance of vegetable cowpea varieties for yield and quality of green pods over two years at IITA, Nigeria**

| Variety | Plant type | Pod yield (q/ha) | | | Pod length (cm) | Moisture content (%) | Protein content (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | green pods | | matured seeds |
| | | 1982 | 1983 | mean | | | fresh weight basis | dry weight basis | |
| IT81D-1228-13 | Bushy | 189.13 | 147.99 | 168.56 | 25 | 89.5 | 2.94 | 28 | 24 |
| IT81D-1228-14 | Bushy | 167.78 | 151.31 | 159.55 | 29 | 89.3 | 2.78 | 26 | 25 |
| IT81D-1228-15 | Bushy | 154.68 | 152.85 | 153.77 | 28 | 89.6 | 2.91 | 28 | 26 |
| TVx 3442-27E | Climbing | 147.67 | 101.51 | 124.59 | 32 | 89.3 | 2.78 | 26 | 25 |
| Dinner Local | Climbing | 125.04 | 87.25 | 106.15 | 31 | 89.1 | 2.73 | 25 | 26 |
| LSD 5% | | 33.56 | 41.81 | | | | | | |

A variety called V 38 with similar bearing habit and edible pods was also identified for release in India in 1984.

COWPEA VARIETIES FOR INTERCROPPING AND DUAL PURPOSE

IITA has developed and distributed a range of improved breeding lines for pure cropping combining multiple disease and insect resistance with early maturity and desirable seed types to over 60 countries [8, 17]. About 50 countries have systematically evaluated the improved materials received from IITA, identified superior lines and released them for general cultivation. A large number of germplasm and breeding lines have been received in India for the first time in 1996. However, all these lines require 2–3 sprays of insecticides to protect against flower thrips, Maruca pod borer, and pod sucking bugs (PSB). This is due to lack of availability of germplasm lines with high levels of resistance to these pests. Most of the farmers in Africa, as also in Asia, do not use chemical protection due to socio-economic and/or infrastructural constraints even though the new varieties, when sprayed, can yield between 10–20 q/ha and give high economic returns. They continue growing cowpeas as an intercrop with millet and sorghum in the traditional manner without insecticide application. Therefore, during the strategic planning review of IITA's research programme in 1986, it was suggested that the cowpea breeding objectives should be diversified to include systematic improvement of traditionally cultivated local varieties which would produce higher grain as well as fodder yields in the traditional intercropping systems. Since then, the major focus of the programme at the IITA Kano Station has been to study traditional cropping systems, identify cowpea production constraints and, in collaboration with national programmes, develop improved cowpea varieties combining disease and insect resistance with better adaptation and high yield potential under intercropping systems of savanna ecologies where soils are poor and moisture is limited. The traditional

**Fig. 2. IT81D-1228-14, a bush type vegetable cowpea with long peduncles holding pods above ground.**

cropping systems are very diverse and differ not only from region to region but also from farmer to farmer within the same region. A list of different cropping systems in the West and Central African savannas is presented in Table 7. The study of traditional cropping systems in the Sudan savanna of Nigeria revealed that farmers grow two types of cowpea varieties: i) an early maturing type for grain purpose, and ii) a late maturing type for fodder, often in the same field planted in alternate rows as intercrops with millet and/or sorghum. Both types of varieties are photoperiod-sensitive and spreading type but they differ in maturity. The apparent limitations in the currently grown local varieties are their susceptibility to many insects and diseases, and very late maturity of the fodder varieties. This gives rise to premature drying if the rains stop early in September. The early maturing grain varieties like Dan Ila, Dan Wuri and Jan Wake are normally planted by June-end and mature by the first week of September, whereas the late fodder varieties, such as Kanan Nado and IAR 1696, are planted in mid–late July and they flower in October. In case of late rains, these varieties produce some grain otherwise they are harvested green and rolled into bales for fodder as soon as they show signs of wilting. The average yield of grain varieties ranges from 0–150 kg/ha depending on insect damage, cropping system, and variety. The grain yield of fodder varieties is even lower.

**Table 7. Cowpea in the cropping systems of West Africa**

| | | |
|---|---|---|
| **A.** | **Forest and Southern Guinea Savanna** | |
| | 1. | Cassava–cowpea |
| | 2. | Maize–cassava–cowpea |
| | 3. | Maize–cowpea |
| | 4. | Maize–cowpea, relay or double crop in second rainy season |
| **B.** | **Northern Guinea Savanna** | |
| | 5. | Groundnut–cowpea |
| | 6. | Groundnut–sorghum–cowpea with or without millet |
| | 7. | Sorghum–cowpea |
| **C.** | **Sudan Savanna** | |
| | 8. | Millet–sorghum–cowpea, relay with or without groundnut |
| | 9. | Millet–groundnut–cowpea |
| **D.** | **Sahelian Zone** | |
| | 10. | Millet–cowpea |

Two approaches are being simultaneously followed for developing varieties for intercropping:

i) *Defect elimination.* Improvement of local photoperiod-sensitive varieties by incorporating resistance to diseases, insect pests, *Striga* and *Alectra* by backcrossing.

Several local varieties have already been improved following partial backcross method. IT88D-867-11 (improved Jan Wake), IT89KD-374-57 (improved Dan Ila), IT89KD-319 (improved Kaokin Local) and IT89KD-288 (improved Kanan Nado) are some of the promising lines which possess aphid resistance and other desirable traits but look similar to the recurring local parents in growth habit and seed quality. They have performed significantly better than the local types.

ii) *New varieties*. Development of a range of completely new varieties with and without photoperiod sensitivity but with higher grain and fodder yield under intercropping.

Performance of three groups of new varieties in pure crop, with and without insecticide spray and intercrop, is presented in Table 8. The data indicate that the early and medium maturing varieties have higher grain yield potential in pure crop as well in intercrop but give less fodder yield because of restricted period of vegetative growth. Similar results were also obtained by Blade et al. [18] using a different set of varieties. On the other hand, the traditional varieties (e.g. Dan Ila, Kanan Nado and Bomo Local) do not produce as much grain even with good management but give higher fodder yield. Thus, there is a need for dual purpose varieties which will give reasonable grain and fodder yield. The grain–fodder cowpea varieties have to combine high grain yield with low harvest index. Therefore, to evolve such varieties, selection for high yield must be carried out among segregating populations and breeding lines producing foliage profusely. IT81D-985 and ID89KD-252 are improved analogues of local type varieties with higher grain but similar fodder yield as the local. Fodder yield can be further increased if the late maturing spreading varieties can be made semierect and more drought tolerant as they utilize vertical space better, making it possible to accommodate more plants per unit area, and stay in the field longer after the rainy season. Parental lines with good growth in poor soils and high level of drought tolerance have been identified and are being used in breeding programme.

The results presented in Table 8 make an interesting reading. It is obvious that as the cowpea genotypes move towards earliness they become increasingly more photoperiod-insensitive (day neutral). In fact, this is a general pattern universally observed in almost all field crops, cereals, oil crops as well as legumes. Earliness, or day neutrality, increases the adaptability of varieties.

More pertinent in the present context is the effect of earliness on the yields of grain and fodder and the escape of early varieties from insect damage. The mean grain yield of the early varieties under complete protection with two insecticide sprays was 17.99 q/ha, which decreased to 16.62 q/ha in the medium and to 5.36 q/ha in late maturing varieties. The yield of early varieties dropped to 39.86% in the pure crop and to 20.12% under intercropping in the absence of protection in relation to the fully protected crop. The reduction in grain yield of the totally unprotected crops in pure and intercropping, respectively, was 30.08 and 23.29% in the medium maturity varieties. The loss suffered by late maturing varieties due to insect damage was even more severe. Their grain yield dropped to 28.17% in pure crop and to 11.38% under intercropping in the absence of protection. Four out of six varieties totally failed under these conditions. On the one hand, this explains the low national yield levels of cowpea in traditional agriculture and, on the other hand, it strengthens the hypothesis that earliness, which is invariably coupled with photoperiod-insensitiveness, leads to wider adaptability and greater stability of yield. The need, therefore, is to enhance

**Table 8. Performance of the most promising early, medium and late maturing cowpea varieties in different cropping systems at Kano, Nigeria, in 1993 (yield in q/ha)**

| Variety | Pure crop (2 sprays) | | Pure crop (no spray) | | Intercrop (no spray) | |
|---|---|---|---|---|---|---|
| | seed | fodder | seed | fodder | seed | fodder |
| **Early maturing varieties (photoperiod-insensitive)** | | | | | | |
| IT90K-284-2 | 24.53 | — | 8.15 | 21.66 | 2.52 | 5.95 |
| IT90K-56 | 19.49 | — | 7.15 | 11.66 | 5.25 | 8.38 |
| IT88D-643-1 | 17.80 | — | 6.25 | 16.66 | 2.41 | 3.53 |
| IT89KD-389 | 17.50 | — | 8.48 | 11.66 | 3.28 | 4.34 |
| IT91K-93-10 | 16.28 | — | 5.41 | 19.16 | 4.08 | 5.50 |
| IT90K-59-4 | 18.72 | — | 8.83 | 12.50 | 4.95 | 4.31 |
| IT84S-2246-4 | 11.59 | — | 5.94 | 10.00 | 2.84 | 4.83 |
| Mean | 17.99 | — | 7.17 | 14.76 | 3.62 | 5.26 |
| Relative yield, % | 100.00 | — | 39.86 | 100.00 | 20.12 | 35.64 |
| LSD 5% | 5.11 | — | 2.57 | 9.77 | 2.01 | NS |
| **Medium maturing varieties (mostly photoperiod-sensitive)** | | | | | | |
| IT90K-277-2* | 23.71 | — | 10.82 | 32.50 | 4.52 | 6.25 |
| IT90K-372-1-2 | 18.71 | — | 6.00 | 14.16 | 2.11 | 1.52 |
| IT88DM-363* | 18.24 | — | 3.66 | 25.00 | 5.69 | 5.42 |
| IT89KD-374-8 | 20.45 | — | 5.39 | 15.83 | 2.79 | 3.08 |
| IT89KD-374-57 | 15.92 | — | 4.61 | 10.83 | 1.96 | 1.48 |
| IAT 48 | 15.75 | — | 3.83 | 28.33 | 4.94 | 6.81 |
| Dan Ila | 3.53** | — | 0.68 | 16.66 | 5.07 | 14.84 |
| Mean | 16.62 | — | 5.00 | 20.47 | 3.87 | 5.63 |
| Relative yield, % | 100.00 | — | 30.08 | 100.0 | 23.29 | 27.50 |
| LSD 5% | 6.64 | — | 5.26 | 14.98 | 2.01 | NS |
| **Late maturing varieties (photoperiod-sensitive)** | | | | | | |
| IT81D-985 | 12.58 | 49.00 | 4.70 | 33.00 | 1.18 | 10.42 |
| IT89KD-252 | 6.30 | 58.00 | 2.01 | 69.00 | 1.02 | 8.33 |
| IT260-1 | 6.17 | 51.00 | 1.04 | 31.00 | 0.74 | 6.46 |
| IT89KD-288 | 3.02 | 57.00 | 1.29 | 37.00 | 0.19 | 12.50 |
| Kanan Nado | 2.05 | 47.00 | 0.00 | 39.00 | 0.55 | 20.83 |
| Borno Local | 2.04 | 48.00 | 0.00 | 43.00 | 0.00 | 22.92 |
| Mean | 5.36 | 43.83 | 1.51 | 42.00 | 0.61 | 13.58 |
| Relative yield, % | 100.00 | 100.00 | 28.17 | 95.82 | 11.38 | 30.98 |
| LSD 5% | 3.09 | NS | NS | NS | NS | 13.19 |

*Photoperiod-insensitive, other varieties photoperiod-sensitive.

**Severe virus infection.

yield potential among the early and extra-early genotypes. The results obtained so far clearly indicate that this is possible.

It can be seen that insect damage does not lead to losses of the same magnitude in fodder yield. The fodder yield of unprotected medium maturity varieties in pure crop decreased from 20.47 q/ha (taken ad 100%) to 5.63 q/ha (27.50%) under intercropping, whereas the grain yield dropped from 5.00 q/ha (100%) to 3.87 q/ha (77.4%). Reduction in the fodder yield of early varieties in the two cropping systems was from 14.76 to 5.26 q/ha (64.36% reduction), as against a decline from 7.17 to 3.62 q/ha in grain yield (reduction 49.51%). The picture, however, reversed in the group of late varieties. The grain yield of unprotected cowpea was reduced to 28.17% in pure crop and to 11.38% under intercropping. The corresponding drop in fodder yield under these two situations was to the level of 95.82% (practically no reduction) and 30.98% in relation to the completely protected crop (two sprays).

## BREEDING FOR STABLE PERFORMANCE

Stability in the performance of improved varieties comes partly from physiological plasticity of the plant and partly from inherent resistance/tolerance to different biotic and abiotic stresses. Cowpea suffers from a large number of diseases and insect pests as well as from moisture stress and low soil fertility in the semiarid regions. The intercrop of cowpea also suffers from shade due to the accompanying tall graminaceous crops (mainly pearl millet, sorghum, or maize). Therefore, concerted efforts are being made to develop improved cowpea varieties with combined resistance to major diseases, insect pests, parasitic weeds like *Striga* and *Alectra*, as well as tolerance to drought and shade. Even though this is a rather vague and long-term objective, good progress has already been made. Sources of resistance to several diseases, insect pests, and parasitic weeds have been identified and the genetics of some of these traits worked out [19–26]. In many fungal, bacterial and viral diseases, resistance has been demonstrated to be monogenic dominant or recessive, which makes it easy to transfer to new varieties [27, 28]. Several advanced breeding lines have been developed with individual or combined resistance to cowpea yellow mosaic, cowpea aphid-borne mosaic, golden mosaic, anthracnose, web blight, bacterial blight, brown blotch, *Septoria*, scab, aphid, bruchid, thrips, *Striga* and *Alectra* [3, 25, 29, 30]. Through systematic crossing and selection, desirable genes are being accumulated in improved genetic backgrounds. The varieties listed in Table 9 are related and show stepwise addition of new desirable genes. IT90K-59 is one of the most promising multiple disease and insect resistant varieties. It carries genes for resistance against 15 out of the 16 biotic stresses listed in the table. It is also being used as a parent in breeding to further pyramid genes for tolerance to drought, shade and good performance in poor (sandy) soils.

**Table 9. Progress in pyramiding genes for disease and insect resistance in cowpea**

| Disease/insect | Resistance status in varieties evolved progressively | | | | |
|---|---|---|---|---|---|
| | Ife Brown (1973) | TVx 3236 (1978) | IT82D-716 (1982) | IT84S-2246 (1984) | IT90K-59 (1990) |
| Anthracnose | S | R | R | R | R |
| Cercospora | S | R | R | MR | R |
| Brown blotch | S | R | R | MR | R |
| Bacterial blight | MR | MR | MR | MR | R |
| Septoria | S | S | S | S | S |
| Scab | S | MR | MR | MR | MR |
| Web blight | S | MR | MR | MR | MR |
| Yellow mosaic | S | S | R | R | R |
| Aphid borne mosaic | S | S | R | R | R |
| Golden mosaic | R | R | R | R | R |
| Aphid | S | S | S | R | R |
| Thrips | S | MR | MR | MR | MR |
| Bruchid | S | S | R | R | R |
| *Striga* | S | S | S | S | R |
| *Alectra* | S | S | S | S | R |
| Nematode | S | S | S | R | R |
| Total resistances | 2 | 8 | 11 | 13 | 15 |

**Note.** The earlier variety in column heads is one of the parents of the variety evolved in the succeeding year.

In the countries of the Indian subcontinent, like most Asian countries, cowpea is a pulse crop of relatively minor importance. This is evident from the fact that in India even authentic statistics on its area and production is not available. It is cultivated all over the country either on small areas for specific purposes or in mixed cropping. However, the situation is likely to change with the wholesale price of white bold seeded cowpea reaching Rs 2000/- per quintal in India.

It is clear from the yield potential of the latest cowpea varieties released for commercial cultivation that this is possibly the highest yielding grain legume crop for kharif season (July–October). As can be seen from the data presented in Table 10, even short-duration varieties like Pusa Phalguni can produce up to 23.6 q/ha of dry grain. A definite trend has set in the Indian cowpea breeding programmes to evolve varieties with erect, compact and terminally bearing growth habit which will change the face of this crop in this region.

**Table 10. Relative performance of commercial varieties of cowpea under different conditions of management in India**

| Variety | Grain type | Disease situation | Highest yield at IARI (q/ha) | Mean yield of multilocation trials (q/ha) |
|---|---|---|---|---|
| Pusa 152 | Buff<br>Medium | Susceptible to bacterial blight<br>Immune to all viral diseases | 23.6 | 8.34 |
| Amba (V 16) | Red<br>Medium | Mildly susceptible to viral diseases<br>Highly resistant to fungal and bacterial diseases | 27.8 | 10.5 |
| V 38 | Red at dorsal surface<br>Fawn at hilum<br>Medium small | Highly resistant to all disease | 22.8 | 9.5 |
| Rambha (V 240) | Red<br>Medium | Most resistant to all diseases | 19.1 | 10.7 |
| V 130 | White<br>Medium | Free from all diseases | 28.1 | 12.0 |

Cowpea breeding is somewhat handicapped in the areas of its concentration (Rajasthan and Gujarat) because of erratic appearance of diseases, that too with low intensity. Northern India with higher rainfall provides ample opportunity to make selections for disease resistance. As a result, all the varieties released at national level were developed at the Indian Agricultural Research Institute (IARI), New Delhi, which combine high yield potential with disease resistance. Pusa 152, a variety evolved about 25 years ago, is still under cultivation because it is almost immune to all viral diseases. Other varieties, besides being highly resistant to diseases, also have semispreading and nontrailing growth habit, which makes it possible to plant them at close spacing in a pure crop, thereby imparting greater stability of yield.

The genotypes with tall or bushy growth habit and cereal-like erect plant have yet to get established in this part of the world. Varieties showing disease resistance in the African continent are not always resistant to the Indian variants of the pathogenic microflora. Nevertheless, the experience gained at IITA and IARI definitely shows the possibility of evolving varieties resistant to all major diseases.

The situation with regard to insect resistance is far more complex. Very convincing sources of insect resistance with simple mode of inheritance and easy transferability have not been found. Bruchid resistant strains received from IITA did not show much resistance against this deadly store pest under conditions of controlled experiment.

In conclusion, it seems that the yield potential and yield stability can be ensured in cowpea with sustained efforts in plant improvement. Since strains have already been developed which grow like a *Vicia faba* plant and bear pods above the plant canopy, the possibility of manipulating plant structure genetically has increased tremendously. Ultimately, it turns out that the general dictum of "ideal plant type = high yielding (early) dwarf" (cf. previous article on pea in this issue, pp. 371–388) is equally applicable to cowpea also. Dwarfness in this context has to be understood in a wider sense. In cowpea, a nontrailing, upright growing plant with determinate growth habit could be called a "dwarf" as compared to the traditional type viny cowpeas. The new cowpea genotypes have the added advantage of producing long peduncles which keep the pods above the crop canopy. Nowhere else such an opportunity exists among the leguminous crops with axillary fruiting habit.

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