ized eggs, while females develop from fertilized eggs. It is predicted that females tend to reproduce by oviparity when there is local mate competition, and by ovoviviparity when constrained by predators with or without local resource competition[3]. Reproductive females which are involved in local resource competition for food and oviposition sites select ovoviviparity as they can retain eggs till a suitable rearing site is located[3].

Therefore, an indepth assessment of aggregation of species in relation to their reproductive output, behavioural diversity of gynaceoid and oedymerous females, egg size and reproductive division of labour contributes to a better understanding of eusociality. Phenotypic changes alter fitness of the genotype in terms of oviposition mediated through mating patterns. Fecundity index expressed as the number of eggs/female as in oviparous forms and number of larvae/female in viviparous forms, is an added measure of sociality. The impact of genetic, phenotypic and ecological causes relating to the structural diversity evident in apterous males as against the macropterous ones, is an aspect deserving further scrutiny in relation to better appreciation of cooperative endeavour evidenced in mycophagous colonies of thrips. The genetic relatedness of the diverse morphs, i.e. egg diversity, clutch size and output of larger eggs, besides competition by females for food and space tends to increase competition. The relationship between body size, armature and reproductive success deserves further scrutiny. According to Wilson[16], 'The transformation of an insect species from a solitary lifestyle to advanced colonial existence, requires alteration in every system of the body, coupled with sufficient plasticity in the traits prescribed by genes among adults castes'. As has been indicated by Hamilton[17], 'the coincidence of male winglessness, female-biased sex ratios, male haploidy and male fighting in spatially structured populations is probably not accidental'. Further studies are needed in relation to diverse mycophagous species to be able to appreciate the diversities expressed and it is needless to emphasize that patterns of sociality, habitat stability and social structure tend to account for sociality in thrips.

1. Crespi, B. J. and Mound, L. A., In *The Evolution of Social Behaviour of Insects and Arachinids*, Cambridge University Press, Cambridge, 1997, pp. 166–180.
2. Kranz, B. D., *Behav. Ecol*., 2005, **6**, 779–787.
3. Kranz, B. D., Shibata, T., Tsuchida, K. and Okajimas, S., *Evol. Ecol. Res*., 2002, **4**, 1045–1092.
4. Crespi, B. J. and Yanega, D., *Behav. Ecol*., 1995, **6**, 109–115.
5. Ananthakrishnan, T. N., *Proc. Biol. Soc. Wash.*, 1961, **74**, 275–280.
6. Ananthakrishnan, T. N., *Indian J. Entomol*., 1967, **29**, 61–64.
7. Ananthakrishnan, T. N., *Ann. Soc. Entomol. Fr*., 1968, **4**, 413–418.
8. Ananthakrishnan, T. N., In *Bioecology of Thrips*, Indira Publishing House, Michigan, USA, 1983.
9. Ananthakrishnan, T. N., Dhileepan, K. and Padmanabhan, B., *Proc. Indian Acad. Sci. (Anim. Sci*.), 1983, **92**, 95–108.
10. Crespi, B. J., *Ecol. Entomol*., 1986, **11**, 119–130.
11. Kiester, A. R. and Strates, E., *J. Nat. Hist*., 1984, **19**, 303–314.
12. Dhileepan, K. and Ananthakrishnan, T. N., *Proc. Zool. Soc. Calcutta*, 1991, **44**, 33–38.
13. Crespi, B. J., *Nature*, 1989, **337**, 357–358.
14. Hamilton, W. D., *Science*, 1967, **156**, 477–488.
15. Hamilton, W. D., Evolution and diversity under bark. In *Diversity of Insect Faunars*. Symposium of the Royal Entomology Society, London, vol. 9, pp. 154–175.
16. Wilson, E. O., *Nature*, 2006, **443**, 919–920.
17. Hamilton, W. D., In *Sexual Selection and Reproductive Competition in Insects* (eds Blum, M. S. and Blum, N. A.), Academic Press, New York, pp. 167–220.

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Farmers' variety in the context of Protection of Plant Varieties and Farmers' Rights Act, 2001

S. Nagarajan, S. P. Yadav and A. K. Singh

The Convention on Biological Diversity was signed at the Earth Summit in Rio de Janeiro in 1992. The Convention asserts that biological resources belong to the sovereign state in which they exist. Inevitably this stand is in conflict with patenting of live forms such as plant varieties. The prior art of this refers to publicly available existing knowledge that is relevant to an invention for which a patent applicant is seeking protection. If the prior art is too closely related to the claimed invention, the application may be rejected on the grounds of lack of an inventive step. The registration officers are required to check for the absence of prior art before awarding a patent. Now this has been well accepted by the Organization of Economic Cooperation and Development (OECD).

Australia, the world's leading advocate of neo-liberal agriculture, is facing a crisis of family farming in sectors where corporate entities are entering into horticulture and dairying, altering the nature of farmer/processor relations. The Australian tomato processing industry has been drastically altered in the last 20 years. During this period 90% of the growers got eliminated, changing the social and economic characteristics of the remaining 10%. In 1984, the average tomato output per grower was 520 t and by 2004, it was around 12,500 t. During the period 1975–2002 the price of tomato fell by almost 70%. The shift has been towards tomato hybrids production technology, large specialized farm and technology-wise, well-informed growers[1]. Clearly, liberal globalization of agriculture is likely to induce several shifts in the present system of farming. A diverse and bio-

resource-rich country like India has to learn from the experiences of others. India must document and legally protect the farmers' varieties (FVs) and use them globally as a trade strategy. The FVs therefore can be equated with the prior art provision of The Patents (Amendment) Act, 2005. Providing necessary legal framework will ensure that already known FVs are not encroached as 'New Variety'.

Innovations have produced FVs

In South Asia, agriculture and crop husbandry are in practice for the last few millennia. Farmers, who selected plants of utility from wilderness, domesticated them by mastering their means of perpetuation. They further selected and modified the traits making the farm produce more palatable, storable and marketable. Through keen observation and innovation, farmers have taken up crop-improvement activities by selecting useful traits, from out of the periodically accruing natural variation.

A number of agencies have initiated programmes to conserve, document, characterize and publicize germplasm adapted to local environments. Their focus has been on conservation of crop diversity, indigenous agriculture and traditional knowledge. Such attempts have primarily focused on cereals and millets such as rice (*Oryza sativa*), ragi (*Elusine coracana*), jowar (*Sorghum bicolor*), grain legumes, etc. Provision has been made under the Protection of Plant Varieties and Farmers' Rights Act, 2001 (PPV&FR Act, 2001)[2] for the registration of FVs and varieties of common knowledge under the generic class 'Extant Variety (EV)'.

FV has been defined under the Act as follows: (i) Has been traditionally cultivated and evolved by the farmers in their fields and (ii) Is a wild relative or land race or a variety about which farmers possess common knowledge.

What is a FV?

The FV is one that has been evolved by farmers/farming communities over several years and has proven special features compared to other materials. These materials must have been traditionally cultivated for considerable number of years. Because of repeated propagation, progeny assessment and advancement, the FV tends to be more homogenous and stable with distinct character(s). Such varieties have been provided with unique identity and with a vernacular name or a name (predominantly) describing their unique features. The distribution or horizontal spread of such FVs in their neighbourhood as unregistered varieties surmises that there has been a consumer acceptance for the produce. This only goes to prove that market-driven selection was done by farmers in the selection of FV. It can, therefore, be confidently said that FVs are those plant varieties that are homogenous, traditionally cultivated by farmers, selected by farmers in their own field and are an improvement over the wild relatives and/or land races. The FV can be elaborated as a variety that is almost uniform, homogenous, distinct trait and enjoys consumer acceptance[3].

FV should meet registration standards

FV is grouped under the class EV, which has been defined in the PPV&FR Act, 2001. The Act further adds that the Registrar shall register the FV within three years from the date of Gazette Notification of the species and genera eligible for registration under the Act. To facilitate the class of EV being registered under the provisions of the Act, further a Gazette Notification was issued informing the constitution of the Extant Variety Recommendation Committee (EVRC). This committee is mandated to develop appropriate procedures and examine the EV applications that fall under the Seeds Act, 1966 and recommend to the Authority the suitability of the material for registration.

Norms for FV registration

The criteria of Distinctiveness, Uniformity and Stability (DUS) to be adopted for the EV may marginally vary from those specified for new varieties. It may also vary between species, depending on whether the candidate is a variety or hybrid. There is paucity of experimental data to indicate the level of distinctiveness that is available between FVs to separate them from one another. The selection criteria followed by farmers have been yield stability, risk avoidance, low dependence on external inputs and attributes related to storage, cooking and taste[4]. The FVs are generally niche-specific and dispersed through informal system of seed exchange[5]. This implies that the special characters would be the main basis of difference, since most of the FVs may not have plant types with spectacular morphological variation. Yet, careful observation reveals perceivable differences for awn length, grain size, ear-head shape, straw strength, etc. Evaluating FVs according to descriptors notified in the *Plant Variety Journal* (*PVJ*) has not yet been done. At best, qualitative and limited passport data are available for the FVs, falling short of the registration requirements. The essential characters and grouping characters are based on UPOV and Indian plant breeder's perception. It needs fresh examination to assess whether the notified descriptors meet the requirements of the FVs as well.

Testing procedure for FVs

The FVs are said to be high performers under low input conditions. This implies that for a FV undergoing DUS test to resolve a tussle, on its registerability is to be conducted under restrictive input conditions. Such changed growing condition should give results comparable to the new variety tested under the recommended agronomic procedure. The type of irrigation and nutrient schedule needed for the pest-vulnerable FV has not been examined scientifically to arrive at any meaningful recommendations.

Distinctiveness between FVs

The traditionally cultivated, farmer-field evolved varieties are invariably tall ideotypes. The FV is likely to possess certain qualitative characters such as aroma, grain elongation on cooking, nutraceutical uses, tolerance to flooding, soil salinity, etc. These characters are of utmost importance and shall call for defined laboratory procedures for assessment. The traditional knowledge associated with the FV should be recorded and the claims must be experimentally validated. Establishing the distinctiveness of the FV material based on the claims made by the applicant can be a demanding decision for the EVRC. The public-funded agricultural research establishments, said to be dedicated to the cause of farmers, should conduct criti-

cal experiments and provide the needed data to farmer/farming communities on an acceptable term, so that they are able to file FVs with all supportive information. When done logically, provincial institutions have reasons to be proud that they have protected the crop genetic resources of their area in a manner benefitting the farmers.

In mass selection, plants are chosen on the basis of the phenotype and the harvested seed composite is advanced without progeny testing. The performance of the mass-selected material is compared with the original seed variant to assess the benefits gained through mass selection. Several single heads selected by the farmer get bulked and the seeds used to re-sow the next crop. This type of seed-chain sustenance permits certain degree of within-field variations. The FV is a product of a type of mass selection (because the farmer willfully retains certain degree of heterogeneity without impairing the main framework of features of the FV) done by farmers to keep purity and homozygosity in an acceptable range, to cushion against environmental aberrations and sustain consumer preferences. Farmers' selection criterion is stability of performance between varying years. Whereas plant breeders conduct mass selection (mass pedigree) to breed varieties to excel in performance. While the approach may sound similar, the objectives are not. The farmer does head-bulking year and again to retain the good combination(s) with certain degree of elasticity (Figure 1). The farmer assesses each year's performance, recollecting back the yield record/trait details retained in his memory. Once he achieves repeatable yield 'fete' with those important traits, then the material is considered fit and the community horizontally spreads the FV over a niche, through seed exchange. These materials being niche-specific (distinct cohesion of morphology, geographical distribution, agro-ecological adaptation and breeding behaviour having their own local names, but has not been selected or maintained for genetic integrity/uniformity) fail to yield the same attributes when grown away from their belt and fail to receive the same level of consumer patronage. The FVs occupy a reasonable area in a given belt and yet may not be dominant variety there.

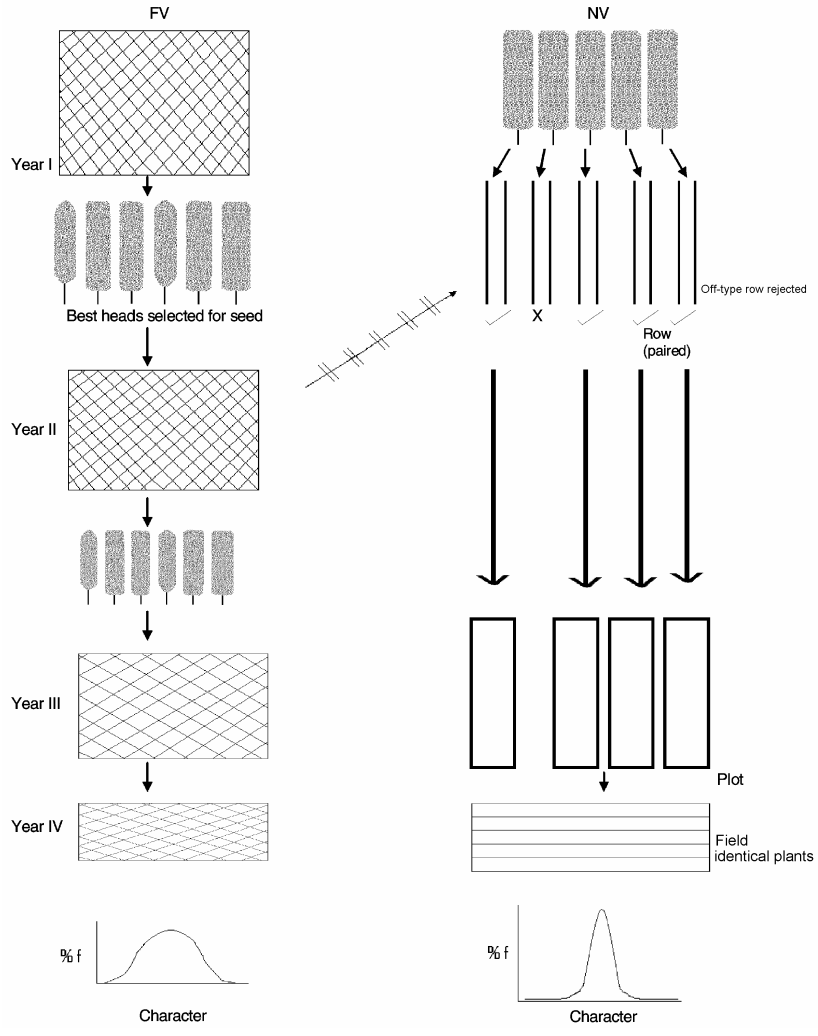

Figure 1. Time scale and differences.

How uniform should FV be?

The selection criteria of the farmer being what they are, one needs to quantify the level of uniformity that is to be prescribed for FV. Since the DUS test is not always advised for FV, evaluating uniformity can be a tricky exercise. It can be done by physically examining an acceptable amount of seed sample for the uniformity of seed features and grain hardiness, etc. Under such a situation the level of seed off-types permissible to infer the extent of uniformity of the FVs should be indicated. There is paucity of experimental data to declare the number of off-types that can be tolerated for FV taking into account that it will assess the stability. Since FV has inbuilt antiquity (according to the definition), it is necessary to scientifically validate the level of non-uniformity tolerated by the farmers and consumers.

Duration of registration of FV

This then leads to the question as to how many years the plant breeders' rights should be granted after the FV is found fit for registration. By definition, FV is one that is traditionally grown and implies that the material has already covered the period of protection prescribed for the new varieties or certain classes of EV. Therefore, providing fresh plant breeders' rights for FVs can only be notional. Hence, a provision would provide access to benefit-sharing, if FV is used

Table 1. Acceptable level of off-types in new variety and farmers' variety

Crop	No. of plants/ replication	Natural out-crossing percentage	Permitted variation in the population	
			New variety/hybrid	FV*
Bread wheat				
Triticum aestivum L.	360	0.5 to 1	2/1000	4
Rice				
Oryza sativa L.	900	~6.8	4/1500 (lowland)	15
			4/1500 (upland)	15
Maize				
Zea mays L. Inbreds and single cross hybrids	120	~95	3/100	5
Variety/other hybrids	240	~95	6/100	10
Sorghum				
Sorghum bicolor (L.) Moench	240	2–10	6/100	10
Pearl millet				
Pennisetum glaucum (L.) R. Br. Inbreds and single cross hybrids	240	~80	3/100	5
Variety/other hybrids	240	~80	6/100	10
Pigeon pea				
Cajanus cajan (L.) Millsp.	150	5–40	4/300	15
Green gram				
Vigna radiata (L.) Wilczek	~140	0–1	4/250	7
Blackgram				
Vigna mungo (L.) Hepper	140	0–1	4/250	7
Lentil				
Lens culinaris Medik	200	0–1	3/250	5
Kidney bean				
Phaseolus vulgaris L.	140	0–1	3/300	5
Chickpea				
Cicer arietinum L.	200	0–0.5	3/100	5
Field pea				
Pisum sativum L.	125	0–0.6	4/300	7

*Suggested level for FV.

further for variety development. If the FV is used in developing a new variety or an essentially derived variety by any breeder, then while granting prior permission owners of the registered FVs can negotiate a deal.

The issue of maintenance of FV

Once registration is granted under the Act, the concerned plant breeder has to do the maintenance breeding of the material and produce true-to-type seeds. In the case of FV, the community intends to do maintenance breeding. Thus adequate care must be ensured so that the variety sustains the main attributes for which the FV got registered. How the seed production chain of FV will be sustained without causing any drift from the initial population is an issue. In the event of granting post-registration field-life for FVs, there is to be a mid-term review and renewal similar to any registered new variety. The new variety on the contrary, is a product of pure line selection system and therefore, is bound to be more uniform than FV, which is a product of bulk head advancement. It is, therefore, obvious that the final product produced by informal plant breeders like farmers is to be viewed and evaluated differently. While the FV may possess distinctiveness they should also be identifiable between generations by visual and taxonomic characteristics, as the same distinct plant variety, without necessarily being uniform for all visual characteristics[6].

Land races and folk varieties

The definition of FV under the PPV&FR Act, 2001 covers the wild relative or land race of a variety about which farmers possess common knowledge. The Biological Diversity Act[7] (BDA) explains the land race as a primitive cultivar that was grown by ancient farmers and their successors. The BDA further defines a cultivar as a plant variety which has originated and persisted under cultivation or was specifically bred for the purpose of cultivation.

Folk variety, which finds a place only in the BDA, is explained as a cultivated variety of plant that was developed, grown and exchanged between the farmers. Here the definition excludes the traditional nature of the cultivated variety, nor is it to be evolved by farmers in their own field. Tradition, like custom, covers a long span of time or generations and the folk variety apparently need not have such a time lineage. Between the FV and folk variety differences are substantial. The folk variety often may not fulfill the obligation of identifiability and thus calls for further effort to separate them into two distinct groups.

Selection from land race

Land race and the locally popular varieties are rather heterogeneous and the culti-

vator keeps it that way, as part of subsistence farming, so as to face the various production uncertainties. Often, plant breeders collect such adapted materials, make mass selection within that population in their experimental farm, assess the benefit gained and release them for cultivation. Such materials are not FVs according to the definition given in the PPV&FR Act, 2001. The UPOV[8] has grouped such materials as new varieties.

FV in the context of cross-pollinated crops and others

The above discussion is primarily in the context of self-pollinated crops such as rice, wheat, french beans, peas, soybean, tomato, etc., where out-crossing is up to 0–5%. But the issue becomes much more complicated when we examine cross-pollinated crops like sorghum, pigeonpea, okra, brinjal, chilli, etc., that are 5–12% out-crossed and cross-pollinated crops maize, pearl millet, gourd, cabbage, carrot, cauliflower, onion, melons, radish, etc. having more than 12% of the seed setting due to out-crossing. The extent of variation in the FV of these crops in farmers' field differs considerably with location and season. An estimate of the extent of off-types that can be permitted for FVs based on reasoning is given in Table 1. On a priority basis, the farm-level heterogeneity in these FVs should be quantified before DUS test norms are framed. Such an argument can be extended to the vegetatively or clonally propagated material, bud sports and for chimerical material. The level of variation in these crops being large, a proper understanding of the concept of FVs as perceived by farmers and consumers is necessary before binding the FVs for a high level of uniformity.

Summary

It is clear that FV is a product of farmers having a long tradition, evolved in their own fields from a non-descriptive heterogeneous land race. The yardstick of DUS for FV needs a fresh look, so that a pragmatic procedure to register the FV under the PPV&FR Act, 2001 can be developed. For crops where within-field variations are high and behave as a population or land race, fresh research efforts are necessary to purify them. Considerable research is necessary to understand the farmers' perception of a variety, and the reasoning behind why they permit certain degree of floating variation in the FVs. It is also intriguing as to why consumers have all along been patronizing products with a certain degree of variability.

1. Pritchard, B., Burch, D. and Lawrence, G., *J. Rural Stud.*, 2007, **23**, 75–87.
2. The Protection of Plant Varieties and Farmers' Rights Act, 2001, Gazette of India, Extraordinary No. 64 dated 30 October 2001.
3. Nagarajan, S., *Curr. Sci.*, 2007, **92**, 167–171.
4. Anon., Green Foundation, Bangalore, 2003, p. 96.
5. Saxena, S. and Singh, A. K., *Curr. Sci.*, 2006, **91**, 1451–1454.
6. Leskin, D. and Flitner, M., Issues in Genetics Resources No. 6. IPGRI, Rome, 1997.
7. The Biological Diversity Act, 2002, Gazette of India, Extraordinary, Pt II, Sec 1, dated 5 February 2003.
8. UPOV, Report, Geneva, 2002, p. 8.

ACKNOWLEDGEMENTS. We thank the participants of the two National Level Consultations held during 1–2 June 2007 at NEHU, Shillong, and 19–20 July 2007 at the Annamalai University, for their valuable suggestions.

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