

STUDIES IN THE MILLET *PANICUM MILIACEUM*, Linn.

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Introduction. The botanical name of this millet *Panicum miliaceum* is derived from the old latin word *Milium* which means millet (Blatter 1935). In Russia this millet is known under the name proso. The common English names of this millet are Common Millet, Hog Millet and Broom Corn Millet. In India it has different names in different languages. In North India it goes under the names *Chehna*, *Chinwa*, *Bansi* and *Vari*. In South India *Variga* (Telugu) and *Panivaragu* (Tamil) are the most common names.

Origin and Distribution. This millet is widely distributed in the world. It has been grown from very ancient times in India, Africa, Southern Europe, China and Japan. It is a recent introduction to North America. In India it is chiefly grown in the Punjab, the United and the Central Provinces, Bombay and Madras. The area that this millet occupies in the whole of India is not available. In the province of Madras its area could be computed to be in the neighbourhood of 500,000 acres. There are two zones in which the main areas of the crop are concentrated, namely the Guntur zone comprising Kistna, Guntur and Nellore districts with about 300,000 acres, and the Madura zone consisting of the districts of Madura, Ramnad and Tinnevely, with an acreage of about 100,000. The rest of the acreage is distributed in small areas in the other districts of the presidency.

According to Komarov (1931) this millet is as ancient as wheat. Its origin is undoubtedly in the old world. Williams (1899) suggests an Egyptian Arabian region as the home of this millet. Burkill (1935) states, "Vavilov (*Full. Appl. Bot. and Plant-breeding*, 26, 1926, P. 180) calls attention to the way in which its rapid growth serves the nomads whose sojourn in one place is apt to be short, and he suggests that it was brought westwards from that great home of nomads, the centre of Asia, and has already obtained a large place in the agriculture of the Slavonic regions of eastern Europe in Roman times". Werth (1937) mentions, "after a consideration of the various theories of Vavilov, Schiemann, etc., it is concluded that the probable spread of this millet started from a broad girdle in North China, through Central Asia, South Russia into Middle Europe". Crozier (1894) is of opinion that this crop was introduced into the United States of America from the old world and Brandon (1932) believes that the Russian emigrants brought this over with them.

Uses. This millet is characterised by its short period of maturity which makes it very suitable as a catch crop. It has a very low water requirement (about two-fifths of what is required for wheat) and is able to evade drought by its quick maturity (Brandon, 1932). In the northern coastal districts of the Madras presidency it is raised as a dry land crop. It is sown in the late sowing season (October - November) and yields about 500 lb. of grain to the acre. In the southern parts of the presidency, it is raised in the cold (dewy) weather, invariably as an irrigated crop, when it yields close on 1000 lb. of grain per acre.

In the old world this millet is cultivated for its grain which is used as human food. In India it is husked, cooked and eaten like rice (Watt, 1901). In America it is used chiefly as a forage crop. Bailey (1922) mentions the following uses of this millet in America: "The seed is fed to stock and is used as a substitute for corn in areas where corn will not succeed and the sorghums will not mature. It is fed particularly to hogs. This practice gives it the name of hog millet. It is also an excellent poultry feed. Its protein content is almost as good as wheat."

Botanical Description. Hooker (1875) and Blatter (1935) have described this millet. In the following brief description we have freely drawn from them and have incorporated our special observations. *Panicum miliaceum*, L. belongs to the tribe *Panicacae*, in the natural order Graminae. It is a herbaceous erect annual with a tendency to tiller freely, growing up to a height of 2—4 feet. It is leafy often up to the panicle and the leaves are linear and slender. The leaf sheaths enclose almost the whole internode. The ligule is short with a fringe of silky hairs. The leaf blade and sheath are very often covered with long hairs arising from conspicuous tubercles.

The panicles are slender, usually curved and nodding with long slender branches which are much divided even up to the fifth degree. The main axis is 6 to 10 inches long and from this 10 to 15 primary branches arise often singly, and sometimes in whorls of two or three along the length of the axis. The lower primary branches are longer and heavier than those higher up. The primary branches give off secondary branches. These again divide up further and further into ultimate thread-like branchlets each of which bearing two and very rarely three spikelets at the tip. The spikelets are about $\frac{1}{8}$ " long and have 4 glumes which are glabrous, unequal, cuspidate and prominently nerved.

- Glume
- I. is small and is about $\frac{2}{3}$ the size of Glume III.
 - II. is almost as big as Glume III.
 - III. is paleate neuter. Sometimes three stamens arise in this flower.
 - IV. is broadly ovate, turgid and cartilagenous. The palea is of similar material. These enclose a full flower consisting of three stamens and one ovary with two plumose styles. There are two fleshy lodicules.

The kernel is firmly surrounded by the indurated shining glume and palea which are often coloured. The ripe grain easily sheds. The kernels form about 70 per cent by weight of the grain.

Anthesis and Pollination. With a view to effect successful hybridisation, pollination studies were made on this crop. They were on the field crop at Coimbatore which was in flower during the month of February 1937, the regular growing season of the crop.

From the appearance of the tip of the panicle at the collar of the flag, to its complete emergence from the flag sheath it takes about one week. The opening of the mature flowers does not wait for the complete emergence of the panicle. The flowers which are at the tips of the panicle start opening within 4 days from the appearance of the panicle. The flowering proceeds from top downwards. It takes about 10 days for the panicle to complete its flowering, though the bulk of the glumes open within the first week. Flowers open between the hours 10 a. m. to 12 noon, though stray flowers could be found to open till 1 p. m.

Coming to a typical individual flower, when mature, its fourth glume and palea slowly open out until they make an angle of about 50° between them. The anthers crowd in a column at the mouth of the slit and gradually slip out from between the glume and palea as they widen out. The stigmas whose long styles are bent and interlocked in the bud stage, release themselves and quickly droop out. The anthers dehisce longitudinally, about half a minute after their first appearance at the slit of the glume. This however varies with weather conditions. If the forenoon is very hot, the dehiscence is almost simultaneous with the appearance of the anthers. If the weather is cloudy, the dehiscence of the anthers is delayed by about a minute. In such weather, the flower opens later and the glumes keep open longer. A flower opens and closes in 5 to 7 minutes normally, depending however upon the weather conditions. The stigmas and anthers remain outside when the flower closes.

This millet is as a rule self-fertilised, though a very small amount of natural crossing does occur. The little interval between the opening of the flower and the dehiscence of the anthers makes this possible.

In this connection it will be interesting to note the experience of other workers in the pollination of this millet. Youngman and Roy (1923) studied the pollination of some lesser millets in the Central Provinces and were of opinion that they were mostly self-pollinated. Knuth (1909) mentions that stigmas and anthers protrude simultaneously and that the anthers approach the stigmas when the glumes close so that crossing is favoured at first and automatic self-pollination is possible later on. In Russia, Belov (1914) finds that pollen is shed within the flower before it actually opens and that self-fertilisation is invariable. He states that some natural crosses have also been met with by some workers on this millet. In Poland, Lewiki (1921) confirming the statements of Belov, notes that the opening of the flower

takes place from about 8 a. m. to 1 p. m. and was of opinion that the slight natural crossing that occurs is caused by insects and not by wind.

Artificial hybridisation. The very short interval between the opening of the flower and dehiscence of the anther makes artificial crossing a matter of very great difficulty. Emasculation has to be done well before there is any risk of taint from the readily available pollen. Youngman and Roy (1923) found that the slight pressure on mature flowers caused by passing the earhead through one's closed hand resulted in the opening of many mature flowers. At the Millets Breeding Station it was observed that on windy days a large mass of flowers opened simultaneously and earlier than usual. This earlier opening under pressure of hand was however found not to be early enough for safe emasculation. What was wanted was a little more time between the opening of the glumes and the dehiscence of the anther so that the emasculation could be done safely and without risk not only from the pollen from the same flower, but also from pollen available at the usual time of mass flowering. By examining the earhead, noting the mature flowers likely to open that day and passing such *individual flowers* gently between the thumb and fore-finger it was possible to induce them to open out earlier, by even an hour before their due time of opening. Flowers take about three minutes to open after the manipulation. The anthers in this case take a little longer time to dehisce and the emasculation is done quickly and safely. The desired pollen is also secured in a similar way. This method is essential for designing crossing work with parents whose F_1 characters cannot be depended upon to give a clue to successful crossing. But in the case of such known characters as purple pigmentation whose dominance over the green throughout is well known, it will be simpler to adopt the contact method of crossing described in detail elsewhere in connection with *Eleusine coracana* (Rangaswami Ayyangar, 1932). This method has been successfully used by Kadam (1935) in the case of this millet.

While at this subject of anthesis it may be recorded that odd instances have been met with in which the third glume which is usually neuter, has borne 3 stamens. These stamens were normal and they dehisced and shed their pollen after the anthesis of the bisexual flower. Another interesting floral abnormality is the presence of a fifth glume with a palea and a grain in between, producing two seeds in one spikelet. This was met with in a sample of seed from Russia (Belov, 1916). The glume and palea in this instance are absolutely like the fourth glume and its palea. The central axis is slightly prolonged and an extra grain borne. Such abnormalities occur mostly in the tip florets of the panicles. The manifestation of this doubleness is not constant in all the plants, nor earheads, nor in all the spikelets. Ten is the largest number of double grains observed in a single head. In a random sample of 50 heads only 21 showed double grains which ranged from one to 10. Most of the heads showed this doubling in one or two spikelets only. When double, the grains are small and not well

set. Beyond being an interesting curiosity there are no economic possibilities in this doubling.

INHERITANCE STUDIES

The study of the inheritance of the characters of this plant is in progress at the Millets Breeding Station. The mode of inheritance of the three characters—Purple Pigmentation, Hairiness, and Grain Colour is presented below.

Purple Pigmentation. As in all cereals, in this millet also there are types with and without purple pigmentation. This millet being slender and the manifestation of pigment sparse, the pigment is not prominent. A close examination has to be made of the various parts of the plant to determine accurately the distribution of the pigment. That the pigmented condition is a simple dominant to the green-throughout condition has been published. (Rangaswami Ayyangar, 1927, 1928 and 1934.) Kadam (1935) confirmed this observation. Since publishing the above, many types of this millet have been under observation. In addition to the green throughout type, two purple pigmented types have been met with, viz., (1) *Purple* type—young plants occasionally purple on lower leaf sheaths, glume tips purple, stigmas purple, and (2) *Light Purple* type—purple seen only at reproductive stage and that under a lens, glume tip very light purple, stigma purple tinged. The commonest South Indian types are the *Purple* ones. Types that are green-throughout are poorly represented. The *Light Purple* type is only met with in varieties from China and Russia.

As in the case of *Ragi* (*Eleusine coracana*) (Rangaswami Ayyangar and Krishna Rao, 1931) a factor (**P**) produces the basic purple pigment of the type met with in the *Light Purple* group. The addition of an intensification factor (**I**) results in the ordinary *Purple* whose genetic constitution is thus **PPII**, the constitution of the *Light Purple* being (**PPii**). Plants that are Green-throughout may be allelomorphic to either of these purple pigmented types. The presence of purple is a simple dominant to its absence resulting in a plant that is Green-throughout. The presence of the intensification factor (**I**) is a simple dominant to its absence, (**i**). The (**I**) factor can manifest itself only in the presence of (**P**). This factorial interpretation explains the 9 : 3 : 4 ratio of *Purple*, *Light Purple* and *Green-throughout* met with in crosses designed to throw light on the inheritance of these factors. The data from the cross is presented in the following table. (Table I). In the tables the abbreviation P. V. stands for *Panivaragu*, the Tamil name of this millet.

Hairiness. Hairiness is a characteristic of this millet. This has been noted in all the descriptions of this plant by various systematic botanists. It is however not known that there are various grades of hairiness in these plants including some which border on hairlessness.

From the examination of the pure lines collected and grown at the Millets Breeding Station for some years, varieties could be classified into four groups according to their hairiness :

(1) The *densely hairy* type. This is the most hairy type. Hairs are densely distributed on both the surfaces of the leaf, on the leaf sheath, stem, node and panicle branches. The hairs are about 5 mm. long, and are best seen on the leaf sheath. There are, on the average 400 hairs per square cm. on the surface of the leaf sheath and the same number is found on the upper surface of the leaves. Pure line P. V. 14 is typical of this

TABLE I. Inheritance of Purple Pigmentation.
CROSS XIX.

Generation	P. V. No	Pigment Groups		
		Purple.	Light Purple.	Green-throughout.
Parents	P. V. 91			Female
	" 19)		Male	
F ₁	" 220	F ₁		
Expectation 9:3:4		104	33	44
		102	34	45
				P=9
	F ₂ (from P. V. 220.)			
Family No.	Character of Selection.			
P. V. 269	Purple	168		
" 259	"	57	18	
" 261	"	25	8	
" 264	"	51	16	
" 265	"	36	11	
" 260	"	38		10
" 263	"	61		20
" 266	"	26		9
" 262	"	129	41	53
" 267	"	27	8	12
" 268	"	79	27	38
" 270	"	97	31	44
" 272	Light Purple.		85	
" 274	"		92	
" 275	"		73	
" 271	"		86	28
" 273	"		69	21
" 276	"		91	29

(2) The *hairy* type. This is slightly less hairy than P. V. 14. The hair length is about 3 mm. As in P. V. 14, the hairs are present in all the plant parts, but not so densely. On the leaf sheath there are about 280 hairs per square centimetre of surface. As a pure line this is separable from P. V. 14. This group is represented by the pure lines P. V. 31 and P. V. 97.

(3) The *sparsely hairy* type. This type of hairiness is less hairy than P. V. 31 and is separable from it in pure lines. The hairs are only about 2 mm. long and are sparse even on the leaf sheaths. On an average there are 120 hairs per square centimetre. The leaves and panicle branches appear to be practically free from hairs. Pure line P. V. 36 belongs to this group.

(4) The *hairless* type. This type is devoid of hairs on the leaf, the upper leaf sheath, stem and panicle branches. This is however not absolutely hairless. The lower leaf sheaths and nodes are slightly scabrous. This type is very distinct from the above three types and is easily distinguished from them. This is represented by P. V. 96.

P. V. 96 is an introduction from South Africa and is the only one of its kind in the collection of pure lines. Though it is a hairless type it is without any economic disability. In yield it is as good as any local economic selection. This is very unusual inasmuch as foreign introductions of this millet have not fared well at Coimbatore. The South African varieties have however been an exception. It is interesting to note that the varieties from the *Northern Circars* and the *Deccan* districts of this presidency are the most hairy and belong to group 1. Those from the central and southern districts are less hairy and belong mostly to groups 2 and 3. In the *Circars*, this millet is cultivated as a rainfed crop, while in the south it is invariably an irrigated crop.

The genetic relationship of these hair groups is interesting. Investigations in the inheritance of this hairiness pursued at Coimbatore show that the *hairless* condition is always recessive to the hairy condition. The *densely hairy* condition is brought about by the presence of three factors whose cumulative effect results in a dense manifestation of hairs on the plant. In crosses between the hairy and hairless types, the F_1 generation plants are less hairy than the hairy parent, but the heterozygous dominants in the F_2 are not easy of separation. This interference with the expression of hairiness in the heterozygous condition results in acute difficulty in the classification into sub-groups of hairiness, in the dominant hairy group. A cross between P. V. 96 (*hairless*) and P. V. 36 (*sparsely hairy*) resulted in a *sparsely hairy* F_1 and segregated into 486 *sparsely hairy* plants and 159 *hairless* plants in the F_2 ($P = .9$). Eight selections were carried forward to a third generation. Of these the four *hairless* selections bred true to hairlessness. Of the four hairy selections, two were true to the *sparsely hairy* character and two segregated again like the F_2 confirming the monogenic difference between the parents.

The second cross was between P. V. 96, the *hairless* parent used in the previous cross and P. V. 97, the *hairy* type. The F_1 was less hairy than the hairy parent and the F_2 gave a 15:1 ratio of *hairy* to *hairless* plants; the actual numbers being 281 and 23 ($P = .4$). The hairy group was inseparable into *hairy* and *sparsely hairy* sub-groups as the one ran into the other. It may be noted that P. V. 97 is from Russia. The plants of the F_2 were short and stunted in growth. The same *hairless* parent P. V. 96 was therefore crossed with P. V. 31, a local variety of the same hairy type as P. V. 97. The F_1 was similar to the last one, and the F_2 segregated in a 15:1 ratio of *hairy* and *hairless* plants, the actual numbers being 564 and 25 respectively ($P = .04$). From this 35 selections were carried forward, 28 *hairy* and 7 *hairless*. In the F_3 , the 7 *hairless* bred pure. Of the 28 *hairy* selections, 15 were pure and were of various indistinguishable grades of hairiness and 13 selections threw *hairless* plants. Out of these 13 segregating families, eight were of the 15:1 type (558 *hairy* and 39 *hairless*, $P = .7$) and five of the 3:1 ratio (139 *hairy* and 43 *hairless*, $P = .7$). This behaviour shows that the presence of a second factor for hairiness increases the amount of hairiness and brings it up to the *hairy* standard.



The third cross was again between the same *hairless* parent, P. V. 96 and the *densely hairy* type, P. V. 14. The F_1 was as expected, less hairy than the *densely hairy* parent. The F_2 segregated in a 63:1 ratio of hairy and *hairless* plants (335 hairy and 7 *hairless*, $P = .5$). The hairy plants in the F_2 were of various grades of hairiness ranging from the *densely hairy* to the *sparsely hairy* condition so that it was impracticable to separate them into definite sub-groups, the heterozygous blends adding to the difficulty. The *densely hairy* type, P. V. 14 is a local variety, typical of the cold weather rained types common in the Guntur district. The hairiness in this type seems thus to be the effect of the addition of a third factor for hairiness.

From the above data it has to be inferred that hairiness is governed by the operation of at least three independent factors, any one of which produces hairiness and that the *hairless* type is the result of the absence of all these three factors. These factors are cumulative in their effect, the intensity of the hairiness increasing with the addition of the factors. These three factors for hairiness have been designated H_1 , H_2 , and H_3 .

Grain Colours. The kernel of this millet is enclosed within the fourth glume and its palea. These two floral parts are indurated and shining. They are of various colours and this colour of the grain is the commonest varietal diagnostic character. The various types of grain colour met with so far and their inter-relationship and inheritance are described below.

Grain colours in *Fanicum miliaceum*. The Common Millet.

		Colour of glume.	Colour of palea.
(1) Dark Olive Grey	...	Dark Olive Grey	Dark Olive Grey
(2) Buff Yellow	...	Buff Yellow	Buff Yellow
(3) Light Olive Grey	...	Light Olive Grey wash	Dark Olive Grey
(4) Light Buff Yellow	...	Light Buff Yellow wash	Buff Yellow
(5) Ivory Grey	...	Ivory Yellow	Light Olive at base
(6) Ivory Yellow	...	Ivory Yellow	Light Yellow at base

Of these six colours Nos. 1 and 2, Dark Olive Grey and Buff Yellow are the colours met with in the Madras varieties. In varieties from Russia, South Africa and China, all the six colours are present. Except P. V. 96 (Ivory Yellow) the other types of grain colours have not taken kindly to their new surroundings at Coimbatore.

The starting point in this grain colour scheme for these six colours is Buff Yellow, which colour operates in wholeness on both the glume and the palea. The addition of the factor O to this basic colour Y results in the Dark Olive Grey colour of grain. The factor O is a simple dominant to o . Crosses between these two colours have given simple 3:1 segregations the total figures obtained being 328 Dark Olive Grey and 101 Buff Yellow ($P = .5$).

The other four grain colours represent stages in the reduction of the expression of whole colour on the glume and palea. Light Olive Grey and Light Buff Yellow represent the first stage. Here the colour of the glume acts

diluted to a mere wash, the palea practically retaining its full colour. This dilution of the colour of the glume is brought about by a factor **L**. The operation of this **L** factor along with the factor **O** is presented in the following table.

TABLE II. The Interaction of the Factors **O** and **L**.
CROSS XXV.

Generation.	P. V. No.	Grain Colours			
		Light Olive Grey.	Dark Olive Grey.	Light Buff Yellow.	Buff Yellow
Parents	P. V. 36				Female
	" 201	Male			
F_1	" 222	F_1			
F_2	Expected 9:3:3:1	83	29	27	10
		84	27.9	27.9	9.3
					P = 9
F_3 (from P. V. 222 family).					
Family No.	Character of Selection.				
P. V. 294	Light Olive Grey	132			
" 299	"	68			
" 291	"	69	24		
" 295	"	51	17		
" 290	"	94		29	
" 297	"	80		28	
" 300	"	42		13	
" 292	"	61	21	22	8
" 293	"	104	32	36	10
" 296	"	88	30	33	9
" 298	"	33	12	13	5
" 301	"	18	5	6	1
" 303	Dark Olive Grey.		82		
" 305	"		79		
" 302	"		64		20
" 304	"		98		31
" 309	Light Buff Yellow.			64	
" 306	"			37	11
" 307	"			29	9
" 308	"			69	24
" 310	Buff Yellow.				86

From the above data it will be seen that a factor **L** dilutes the colour on the glume and that it is independent of the **O** factor in inheritance. The interaction of these two factors **O** and **L** results in the production of the four grain colours:— Dark Olive Grey, Buff Yellow, Light Olive Grey and Light Buff Yellow.

A second factor designated **I** inhibits the expression of colour on the glume making the glume Ivory Yellow. The effect of this inhibition is also felt on the palea. The colour of the palea is reduced and is confined to its base. This inhibition factor has also proved a simple dominant to whole colour. The interaction of the **I** and **O** factors is presented in the following table. (Table III).

From this table it will be seen that the inhibitory factor **I** operating independently of the **O** factor gives rise to the colours Dark Olive Grey, Buff Yellow, Ivory Yellow and Ivory Grey.

TABLE III. The Interaction of the factors L and O.

CROSS VII.

Generation	P. V. No.	Grain Colours			
		Ivory Grey	Dark Olive Grey	Ivory Yellow	Buff Yellow
Parents	P. V. 96			Female	
	" 31		Male		
F ₁		F ₁			
F ₂	P. V. 129	337	94	117	41
	Expected 9 : 3 : 3 : 1	331.4	110.4	110.4	36.8
					P = .3
	F ₃ P. V. 129 family				
Family No.	Character of Selection.				
P. V. 157	Ivory Grey		95		
" 168	"		15		
" 167	"		10	3	
" 175	"		22	7	
" 176	"		5	2	
" 158	"		83		26
" 159	"		69		27
" 160	"		34		10
" 170	"		65		19
" 161	"		53	17	14
" 162	"		34	12	10
" 164	"		16	5	5
" 169	"		33	11	12
" 172	"		44	20	14
" 186	Dark Olive Grey			92	
" 187	"			69	
" 189	"			121	
" 163	"			17	9
" 171	"			34	8
" 185	"			59	20
" 188	"			47	16
" 190	"			46	11
" 182	Ivory Yellow				87
" 183	"				26
" 177	"				3
" 179	"				6
" 180	"				23
" 181	"				20
" 184	"				26
" 191	Buff Yellow				56
" 192	"				64
" 193	"				56
" 194	"				58
" 195	"				82
" 196	"				81

Reddish Orange Coloured grain. This third whole-colour is a new one that was met with in the Russian and Chinese collection. The crop raised from this seed did not grow well and seems unsuited to Coimbatore conditions. This type was crossed with Buff Yellow, the starting point in the grain colour scheme presented above. The results of this cross are presented in the following table.

TABLE IV. Grain Colours Buff Yellow and Reddish Orange.
CROSS V.

Generation	P. V. No.	Grain Colours	
		Buff Yellow	Reddish Orange
Parents	P. V. 36	Female	
	" 97		Male
F ₁		F ₁	
F ₂	" 128	289	106
	Expected on 3 : 1 basis	295	99 P = .4
F ₃ (from P. V. 128 family)	Character of		
	Family No.	Selection	
	P. V. 147	Buff Yellow	
	" 149	"	
	" 156	"	
	" 148	"	31
	" 150	"	18
	" 151	"	33
	" 152	"	26
	" 155	"	24
	" 153	Reddish Orange	114
	" 154	"	132

From the above table it will be seen that the grain colour Reddish Orange is a simple recessive to Buff Yellow. A factor B_f suppresses the red in this Reddish Orange and leaves the grain Buff Yellow in colour. Reddish Orange grains have the genetic constitution $YYb_f b_f$, the Buff Yellow grains being $YYB_f B_f$.

SUMMARY

The names, origin and distribution of the common millet *Panicum miliaceum*, Linn. are given in detail with a full botanical description of the plant. A review of the experiences in the anthesis and pollination of this millet is given together with a record of the observations at Coimbatore. For successful hybridisation it is found necessary to have a safe interval between the emergence of the anther and its dehiscence. It has been possible to secure this interval by proper manipulation of individual mature flowers, one hour before the usual opening time. Rare instances have been noted of the third glume bearing anthers and of the existence of poorly formed double grains, the doubling being brought about by the addition of an extra pair of fertile glume and palea.

There are two types of Purple Pigmentation in the plant, the Purple and the Light Purple. In the absence of the P factor for purple pigmentation the plants are Green Throughout (pp). P is a simple dominant to p . An intensification factor I makes the difference between the Purple and Light Purple types. Purple ($PPII$) is a simple dominant to Light Purple ($PPii$). A 9 : 3 : 4 ratio is obtained between Purple, Light Purple and Green Throughout.

The characteristic hairiness in the common varieties of this millet is governed by the operation of at least three independent factors any one of which produces hairiness. The hairless type is the result of the absence

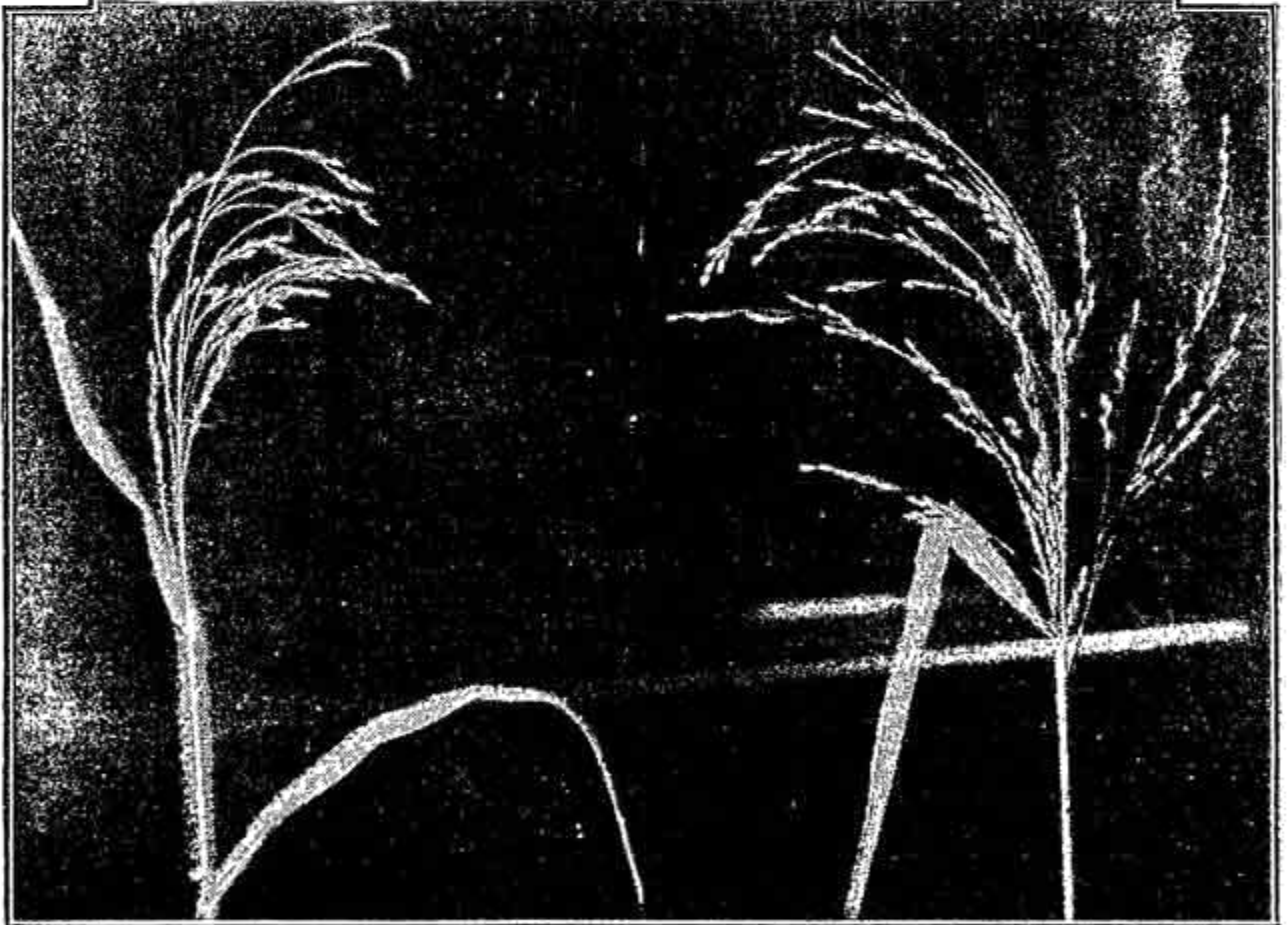
of all the three factors for hairiness, namely H_1 , H_2 , and H_3 . These factors are cumulative in their effect, the intensity of the hairiness increasing with the addition of each H factor. The *densely hairy* type is H_1 , H_2 and H_3 .

The common grain colours in the Madras varieties are Dark Olive Grey and Buff Yellow. A simple dominant factor O makes Buff Yellow into Dark Olive Grey. A second factor L lightens these two grain colours and produces the colours Light Olive Grey and Light Buff Yellow. Factor L which lightens the colour on the glume is a simple dominant to its absence. A third factor I inhibits the expression of colour on the glume making it Ivory in colour. It affects the palea also and restricts the colour to its base. Factor I is a simple dominant to its absence. The two grain colours Ivory Grey and Ivory Yellow are the result of the operation of this I factor. Reddish Orange, a third whole colour, is a simple recessive to Buff Yellow. A simple dominant factor B_f suppresses the Red in the Reddish Orange producing the Buff Yellow.

Literature Cited.

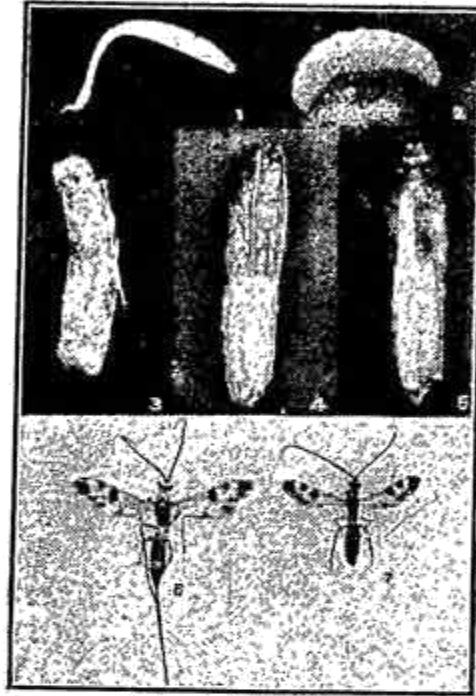
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Panicum Miliaceum, L.



Densely Hairy.

Hairless.



Top left :	Egg—magnified.
Top right :	Grub—full grown.
Middle left to right :	Cocoon,
	Pupa—ventral view and
	Pupa—dorsal view.
Bottom left :	Adult—female.
Bottom right :	Adult—male.