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Preliminary Note on the Rice Crop in the United Provinces

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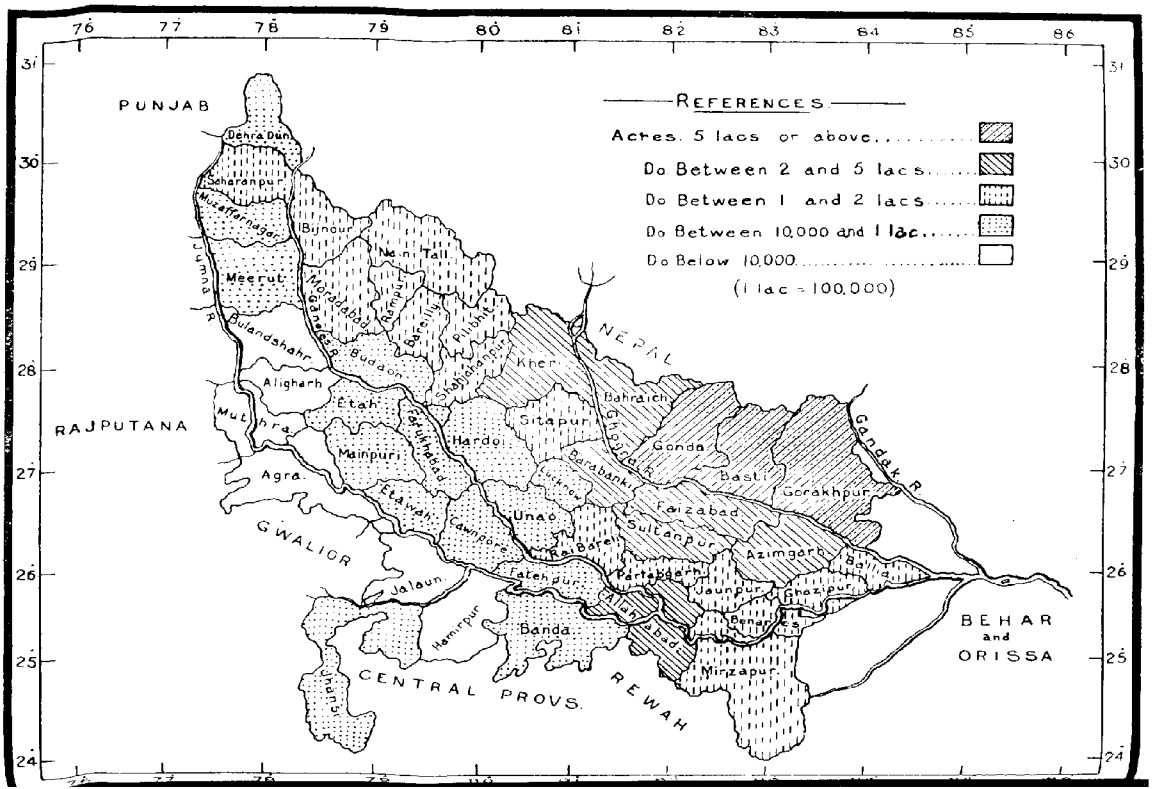
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A Preliminary Note on the Rice Crop in the United Provinces.

(Received for publication on the 9th June 1928.)

Rice is an important crop in the United Provinces and forms the staple food of about 75 per cent. of the population. Previous to 1924 no experiments were carried out on this crop and little or no literature on the subject existed. At that time it was decided to undertake a detailed study of rice and to record as much information as possible on the cultivation of this crop. The preliminary results are recorded in this paper. The first portion is descriptive, the second deals with the experiments in progress which were designed to discover the most likely direction of improvement. These experiments were conducted simultaneously in three typical rice growing regions—the upland valleys, the great plains and the *tarai* region (a strip of territory adjoining the Himalayas)—and are concerned with methods of sowing, cultivation, transplanting, manuring and the selection of seed. Although these experiments are not yet completed, nevertheless the results so far obtained point to definite conclusions.

I.—Descriptive.

The distribution of the rice crop.

Rice is extensively cultivated throughout the province. In 1926-27 (the latest year for which figures are available in the report),[1] it occupied 7,437,361 acres out of a total of 34,283,218 acres under cultivation. As regards area which takes the second place, it occupies, 6,714,010 acres—19·5 per cent. of the total area under crops.

The area in 1926 in the various districts of the province are given in Table I together with the rainfall. The year selected, 1926, was fairly normal both as regards the distribution of the rainfall and the area under cultivation. The general distribution of the crop will be clear from the map. It will be seen that rice is chiefly cultivated near the hills and that the most important area occurs between the Gogra and the Gandak in the north-eastern corner of the province.

[1] Season and Crop Report, United Provinces, 1926-27, Govt. Press, Allahabad.

TABLE I.

Area under rice in the various districts.

District	Area in acres (1926)	Rainfall in inches (1926)
Dehra-Dun	23,905	84·01
Saharanpore	128,416	33·51
Muzaffarnagar	39,421	27·26
Meerut	20,790	25·39
Bulandshahr	2,593	21·28
Aligarh	2,780	27·04
Muttra	5	36·39
Agra	64	29·38
Mainpuri	35,490	37·09
Etah	19,501	29·96
Bareilly	221,094	43·95
Bijnor	167,038	37·28
Budaun	49,336	30·56
Moradabad	147,326	31·26
Shahjahanpur	146,178	35·02
Pilibhit	159,813	58·59
Farrukhabad	37,085	22·86
Etawah	32,654	29·84
Cawnpore	41,256	29·96
Fatehpore	90,982	30·84
Allahabad	237,421	37·19
Jhansi	20,692	44·87
Jalaun	151	34·78
Hamirpur	3,147	43·87
Banda	93,958	49·44
Benares	154,647	43·62

TABLE 1—*contd.*

Area under rice in the various districts—contd.

District	Area in acres (1926)	Rainfall in inches (1926)
Mirzapore	205,876	46·18
Jaunpore	163,990	32·18
Ghazipore	151,122	41·19
Ballia	139,034	38·80
Gorakhpore	988,116	37·93
Basti	688,043	48·72
Azamgarh	350,842	31·15
Naini-Tal	103,215	68·06
Almora	..	..
Garhwal	..	..
Lucknow	57,078	37·87
Unao	92,962	36·45
Rai Bareli	211,889	35·79
Sitapore	226,434	39·07
Hardoi	99,114	34·38
Kheri	235,217	33·87
Fyzabad	288,590	38·94
Gonda	550,456	36·24
Bahraich	378,331	45·64
Sultanpore	258,866	36·54
Partabgarh	135,962	31·25
Bara-Banki	236,480	40·57

From the point of view of the rice cultivation, the province may be divided into three regions, each possessing distinctive characters of its own. These are as follows:—

(*a*) *Mountainous and high regions.* These regions are situated in the north-west corner of the province. They are offshoots of the Siwalak

range of the Himalayan mountains. They constitute the four Districts of Dehra-Dun, Garhwal, Almora and Naini-Tal. The soil is formed of weathered rock and is porous and gravelly. The fields are small and are arranged in terraced beds. The rainfall is heavy, especially in Dehra-Dun where it amounts to 84 inches from April to November. Irrigation is effected by hill torrents which by nature of their movement on rocks are rich in solid material (Table IV) and consequently add sufficient amount of food to the land. Well-irrigation is rare in these parts because of the greater depth of the spring level. The slope is sufficient for good drainage. The regions being elevated are cooler than others and produce early ripening, fine rice. Dehra-Dun rice, specially a variety called *bansmati* (Plate I, fig. 1), has a reputation for its quality as one of the best table rice.

(*b*) *The plain region.* This consists of the central part of the province including the fertile Gangetic plain. It is a flat and fertile area extending from Saharanpore to Ballia and bounded by the rivers Gogra and Jumna. The soil has different characteristics in different parts. It is a light loam in the level portions, a sandy loam on the higher grounds and clayey in the depressions. Rice is sown in rotation with other crops and has a varying degree of importance at different places, depending on the nature of the soil and the availability of water. The rainfall varies from 30 to 40 inches. In the western districts irrigation is mostly done by canals while in the eastern part of the province it is done from wells, ponds and artificial reservoirs. These reservoirs store the rain water and during drought this water is lifted by a *beri* (swing basket) or a *dhenkali* (a crude lever arrangement). A wide range of varieties exists. Generally speaking, the cultivation of early varieties is carried on in the western and late varieties in the eastern districts.

(*c*) *The tarai.* It is a narrow strip of land stretching all along the northern boundary of the province at the foot of the Himalayas. It extends from Pilibhit to Gorakhpore and has a varying range of width at different places. The northern half of the Districts of Pilibhit, Kheri, Bahraich, Gonda, Basti and Gorakhpore constitute this belt. The soil is clayey and retains moisture to a great extent. The high water-level in the soil and the wetness of the climate render the irrigation less essential. The rainfall varies between 40 to 50 inches. A very common practice is that of surrounding the paddy fields by low embankments in order to hold up the rain water. Owing to heavy rainfall and deficient drainage, the weather remains humid. The whole belt is mainly a rice producing area and suits the cultivation of late varieties. The quality varies in different parts depending on the nature of the soil and situation of the land.

Cultivation.

There are three principal methods of cultivation in the province—broadcasting, transplanting and marsh cultivation.

(*a*) *Broadcasting.* This is known as *ushan, bhadain* or *kuari* (after the name of the month in which the crop is harvested), or *sathi* (after the name of an important variety which is sown broadcast)—Plate I, fig. 2. Broadcasted rice is an early maturing crop and out of a total of 7,437,361 acres under rice in 1926, 4,838,082 acres, or 65 per cent., was raised by this method. The sowing of this early crop is dependent on the rainfall. If the monsoon begins early, the maximum area is broadcasted, later if the rains are delayed the area is reduced. The seed is sown fairly thickly (about 80 lb. per acre) immediately after the first shower of the monsoon. Sometimes, especially in the eastern districts, the seed is sown in the dry seed bed. Germination takes place only when the rains set in. This dry broadcasting saves the time of cultivators. After they have germinated, the young plants need no further attention till the harvest unless there is a long break in the rains. If the season is dry, then all possible sources of irrigation, such as streams, canals or ponds, are utilized. On the other hand, if due to excess of moisture the fields are weedy, they are ploughed when the plants are about a foot high. This inter-ploughing, which resembles the practice of *beushaning* in Orissa as described by Basu,[1] uproots about 5 to 10 per cent. of the plants, but helps a great deal in removing the weeds and increasing the tillering capacity of the plants. Sometimes, more especially in the eastern districts, minor crops such as *khesari* (*Lathyrus sativus* Linn), *kodon* (*Paspalum scrobiculatum* Linn) and *arhar* (*Cajanus Indicus* Spreng) are sown mixed with the crop. This is done as a safeguard against failure of the rice in the event of drought.

The crop ripens in August or September and the plants are cut by the sickle and thrashed. The varieties sown are generally of poor quality and are consumed by the poorer classes. The outturn of unhusked rice varies from 800 to 1,000 lb. per acre of which about one quarter represents the weight of the husk.

Early rice is invariably followed by one of the leguminous crops generally by peas in the eastern and by gram in the western districts. This practice of raising two crops in one year is known as *do-fasli* and has been the chief cause of the extension of early rice cultivation. Broadcast sowing is very popular with the Zamindars as the crop leaves the land free in good time for the next *rabi* (spring crop) cultivation.

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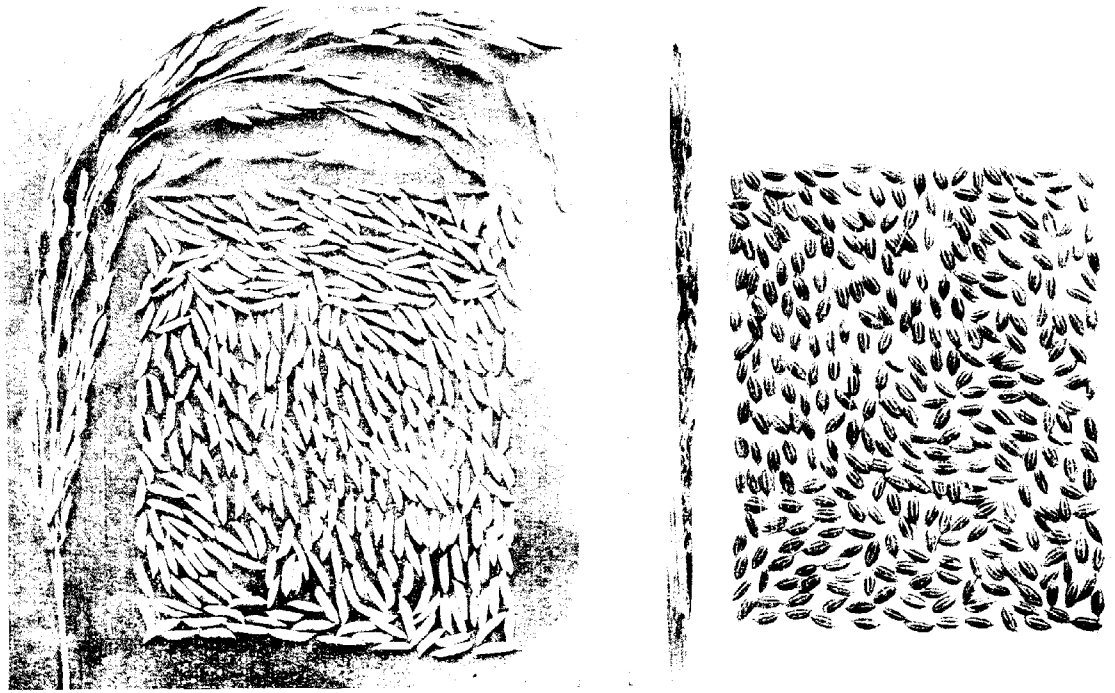
[1] Basu, S. K.—Green manuring of broadcasted paddy in Orissa. *Agri. Jour. India*, vol. XVI, 1921, p. 689.

(*b*) *Transplanting.* This is known as *jarhan, jardhan, ropa* or *aghani.* The last name arises from the fact that the crop is harvested in the month of *aghan* (November). It is a late crop as it takes longer to ripen than broadcast rice. It occupies about 35 per cent. of the total area under rice. Taking the province as a whole, the proportion of cultivation of early to late varieties is about 2 to 1. Out of all the Divisions of the Province, Benares is the only Division where the late crop grows in excess over the early. The seed is sown in a well prepared and heavily manured nursery and the young plants, after about a month and ten days' growth, when they are 10 to 18 inches high, are planted out in the rice fields. The normal time for transplanting extends from the beginning to the end of July. About 40 to 50 lb. of seed is used for covering one acre of the field. The fields are ploughed and puddled in water and are specially prepared, before they are ready for receiving the seedlings. In certain Districts, such as Dehra-Dun, Pilibhit and Kheri, instead of transplanting, sprouted seeds are sometimes sown broadcast on well prepared puddled land. The object of this practice is to save time. It gives a good yield if the rains are timely. Transplantation is much delayed and a part of the growing season is lost if the rains stop by the end of July or early in August. Further any deficiency of rain in September causes serious loss except where a great deal of water is available. Generally speaking, the sowing and the transplantation is done a little later in the eastern than in the western districts. The crop is generally harvested by the end of November. The times of these different operation, vary according to the season and the local conditions of the particular tract. The outturn is from 1,200 to 1,400 lb. to the acre.

The advantages of transplanting are a marked increase in yield, an improved quality and a considerable saving in seed. The disadvantages are the large amount of labour needed at one time, the long time the crop occupies the field and a frequent and opportune supply of water. Transplanted rice is finer than broadcast (Plate I) and is consumed by the richer people. It also forms an important article of export from the principal rice trading centres, such as Dehra-Dun, Gorakhpore and Benares.

(*c*) *Marsh rice.* It is generally known as *boro*, summer or *jethi dhan*, because of its being harvested in the month of *jeth* (May-June). It is also known as *kundhar* in Rohilkhand. Properly speaking, it is a *zaid* (intermediate) crop. It is commonly grown on the margin of lakes and ponds in Gorakhpore and Oudh. Its cultivation is carried on in those parts of the province where the requisite slimy soil is found in the beds of the lakes. The seed is sown during December or January in a nursery



1. *Bansmati* (fine).

2. *Sathi* (coarse).

Typical examples of fine (transplanted) and coarse (broadcasted) rices of the United Provinces.

PLATE I.

and transplanted in February. In May the crop is ready for harvesting. Although the yield is good and is equal to that of late transplanted rice, yet it requires more labour and the grain being coarse and ill-flavoured, is eaten only by poor people.

Two other subsidiary types of rice also deserve mention. The first is *bhenta*. Its cultivation is chiefly practised in Rohilkhand. The seeds are sown with the *boro* rice and after the latter is harvested, the stalks of *bhenta* are left to grow during the rains. It grows well only in stationary floods. The crop is ruined by a too sudden rise in water. Under favourable circumstances the *bhenta* rice is harvested in October. Only the ears with a foot and a half of straw are harvested, the rest of the plant is left to rot on the land, or gathered and burnt. The yield is good but the crop is uncertain. It is considered a spontaneous product because once the seed is put in with the *boro* rice, no further labour is required.

The second type which is of greater importance is wild rice. The common types seem to agree with *Oryza sativa* var *fatua* Prain [1] and *Hygrorhiza aristata* Nees [2]. Stray plants of *Oryza rufipogon* Griffith and *Oryza coarctata* Roxb are also met with. Its common names are *pasahi*, *tinni* and *partal*. It is found all over the province growing mostly in slow running channels, tanks and swamps. Those growing in tanks are usually tall, have weak stems, and are late ripening. They adapt themselves to the depth of water in which they grow. Its chief distinction from the cultivated rice is that its spikelets are very deciduous and are stoutly awned. The rice is of inferior coarse quality and is eaten by the poorer classes. *In Bundelkhand, specially in Jhansi, it is eaten by all classes on the festival of harchauth.*

Methods of husking.

Two methods are generally employed for separating the husk from the rice grain. The first is known as *sela* or *bhujia* system. In this the grain is first put in water for about 30 hours and then taken out and stored in a heap in a corner for about 6 hours covered with gunny cloth. After this, it is dried first in the frying pan, then for about two days in the sun. It is then ready for husking which is done with the help of a *dhenkali* (a crude form of mortar and pestle). The other method is known as the *kacha* system. This is the ordinary way of pounding in a mortar at home or by rice-huller without undergoing the wetting and

[1] Prain, D. *Bengal Plants*, p. 1184.
[2] Duthie and Fuller,—*Fodder grasses of northern India*, 1888.

drying process. The former is advantageous as, unlike the *kacha* system, the rice does not break in husking.

Weeds and other pests.

The rice planter encounters considerable difficulty through the invasion of his fields by a multitude of weeds. The majority of these in their early stage are difficult to distinguish from the young rice plant. Common weeds are *wild kodon* or *makra* grass (*Eleusine Aegyptiaca* Desf) and *sanwank* or *dhand* (*Panicum Crus-galli* Linn). The admixture of wild rice with white rice also reduces greatly the market value of the latter. Great caution is therefore required on the part of the grower to secure and plant seed that is free from it.

The control and eradication of weeds depend upon the frequency and thoroughness of cultivation which should be continued as long as weed growth is noticeable. A change of rotation and leaving the land fallow for a year or two is also beneficial.

A common disease is sterility of the rice heads. The ears in such cases instead of drooping, stand up straight. It may be due to various causes, such as hot winds, drought, poor land, a nematode (*Tylenchus* Sp.) or a Fungus attack.

The insect which most severely injures the rice plant and causes the greatest damage to the crop in the United Provinces is the rice-sapper, an evil-smelling fly called *gundhi* (*Leptocorisa varicornis* Fabre). It often destroys half the crop of a whole locality or district. The mode of parasitism has not been studied but it seems that if for two or three seasons, due to imperfect cultivation, they get a chance of rapid multiplication, the attack becomes epidemic in character. They all cluster together on ripening ears and suck out the milky juice. They generally multiply from the middle of August to the middle of October and, therefore, mostly attack the early maturing kinds. According to Lefroy,[1] the rice fields in Bengal contain members of a very active type of blue beetle (*Cincindela sexpunctata* F.) which feed upon the rice bug. It will be interesting to introduce that beetle into the United Provinces and to see how far it is successful in preying upon the bug.

So far no satisfactory treatment has been found. Catching and killing the insects by means of bag nets was the only method which was found useful in reducing their number. Besides, keeping the fields free from weeds and application of powdered cake of *neem* (*Azadirachta Indica* Juss) was found helpful in lessening the attack.

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[1] Lefroy, H. M.—*Indian Insect Pests*, p. 118.

It is interesting to note that the *gundhi* is absent in the upland valley, is more in the eastern than in the western part of the province and is most prevalent in the north-eastern Districts of Gonda, Basti, Gorakhpore and Bahraich. Obviously it holds a relation to the soil and the climatic conditions. This is a point of interest and the matter is being further investigated.

II.—Experimental.

The experimental work consisted of three parts, *viz*:—

(A) Examination of natural factors affecting rice production.
(B) Cultural experiments.
(C) Manurial experiments.

(A). NATURAL FACTORS.

The important natural factors which influence the cultivation of rice are topography, temperature, soil, rainfall and irrigation water. The situation and the general characteristics of the three typical rice growing regions have been described before. Three places, namely, Doiwala (Dehra-Dun), Cawnpore and Tulsipur (Gonda), were selected as representatives of the mountainous, the plain and the *tarai* region, respectively, for trial experiments. Table II shows the mechanical and Table III the chemical analysis of soils of these places.[1] Table IV shows the analysis of the irrigation water.

TABLE II.

Mechanical analysis.

	Percentage fine gravel and coarse sand	Percentage fine sand	Percentage silt	Percentage fine silt	Percentage clay
A. Doiwala (Upland valley)	9·51	26·75	15·96	22·90	12·10
B. Cawnpore (Plain) . .	0·70	48·74	27·44	21·46	8·79
C. Tulsipur (*Tarai*) . .	0·63	6·22	24·57	22·19	21·50

[1] These were very kindly made for me by Mr. H. N. Batham, Agricultural Chemist to Govt., Cawnpore.

The soil at Doiwala is sandy and gravelly, while that at Tulsipur is clayey. The Cawnpore soil is more or less intermediate in texture. The rain water penetrates easily through the loose particles of the soil of the upland valley. It never accumulates for long in the field. This easy drainage brings about soil aeration, which, according to Howards,[1] is essential for the proper development of the root system. In the *tarai* on the other hand, the colloidal matter of clay makes the soil more or less impermeable. The drainage is difficult and the rain water accumulates. This difference in the texture of the soils is the probable reason for the difference in the yield and quality of *dhans* (unhusked rice) produced in these regions. The rices of the upland valley are early, fine and fragrant, while those of the *tarai* are late, comparatively coarse and less fragrant. As regards yield, it is more in the latter than in the former region. This is in accordance with the views of Warth [2] who states that soil texture exerts a more marked effect upon the yield of paddy than the soil reaction or the presence of large or small amount of plant food.

TABLE III.

Chemical analysis.

	Per cent. Soluble and insoluble silica	Per cent. Moisture	Per cent. Organic matter	Per cent. Nitrogen	Per cent. K_2O	Per cent. Na_2O	Per cent. CaO	Per cent. Fe_2O_3 and Al_2O_3	Per cent. P_2O_5	Per cent. MgO	Per cent. $CaCO_3$	Per cent. SO_3
A. Doiwala (Upland valley).	76·57	2·04	6·92	0·11	0·44	0·50	2·06	10·73	0·57	0·87	5·11	0·05
B. Cawnpore (Plain).	79·48	3·00	3·86	0·05	1·73	0·57	1·20	11·27	0·45	0·16	0·89	0·08
C. Tulsipur (*Tarai*).	71·80	3·00	7·99	0·04	1·61	0·49	2·18	13·82	0·48	0·14	5·41	0·14

These analysis show only slight variations in the food materials in the different soils but there is nothing very significant in a particular soil which may effect the growth of the plant to a considerable extent.

[1] Howards, A. and G. L. C.—"The Economic significance of root development of Agril. crops." —*Agri. Jour. India*, vol. XII, 1917. Also Soil erosion and surface drainage —*Pusa Bull.*, 53.

[2] Warth, F. J.—Notes on the soil of the experimental Farms. *Dept. Agri. Burma—Bull.*, 13, 1916, p. 5.

TABLE IV.

Analysis of irrigation water.

Description	Parts per million Nitrogen	Parts per million total solids	Parts per million Chlorine	Parts per million Sodium Chloride	Parts per million $Na_2 Co_3$
1. Irrigation water from a hill torrent—Doiwala (Upland valley).	18·61	460·80	21·30	35·10	180·20
2. Irrigation rain water and torrent water from a rice field—Doiwala (Upland valley).	12·52	325·20	14·20	23·40	137·80
3. Irrigation rain water from the rice field, Botanical Farm, Cawnpore (Plain).	5·35	75·20	7·10	11·70	58·30
4. Irrigation rain water from the rice field near Tulsipur (*Tarai*).	6·57	104·00	14·20	23·40	42·40

Irrigation water from hill torrents, in the upland valley, is far richer in solid materials than the plain or the *tarai* water. These materials are obviously obtained from the weathered rocks over which these streams flow. It adds sufficient amount of food material to the soil and thus renders, to some extent, the application of manures less essential.

(B). CULTURAL EXPERIMENTS.

In the following Tables the outturns are given in pounds per acre. Seeds of some pure variety of the main crop was sown and transplanted. Different varieties were sown in different experiments. Varieties ripening within 130 days after sowing are counted as early ripening, those ripening between 130 to 150 days as intermediate and those requiring still longer period for maturity as late varieties. For the sake of uniformity, a bed of $20' \times 108'$ (0·05 acre) was used for all the trials. Unless otherwise stated, the plots were arranged in duplicate, simultaneously at three places for two years. Two similar varieties were tried in each experiment. The figures are the average of 8 trials. Single seedlings were transplanted throughout at a distance of 9 inches between rows and

6 inches between plants, except in those experiments dealing with number of seedlings and spacing.

1. Cultivation experiments.

Generally speaking, no summer cultivation is done in the province. Experiments were conducted to see if summer ploughing was useful. A piece of land was given 2 to 3 ploughings from April to June and the plants sown in it were compared with the piece left untouched till sowing time (July). From the figures of yield shown in Table V, it is clear that it pays to plough the land during the hot weather rather than to leave it uncultivated. Hot weather cultivation also helps to kill weeds and insects.

Table V.

The effect of hot weather cultivation.

Treatment	Doiwala		Cawnpore		Tulsipur	
	Grain	Straw	Grain	Straw	Grain	Straw
Ploughed in the hot weather.	2,090	2,698	1,900	3,971	1,748	4,275
Unploughed . . .	1,710	2,280	1,520	2,983	1,444	3,743

An early ripening variety was sown at three places.

2. Transplanted and broadcast rice compared.

It is a well-known fact that transplanted rice gives a larger outturn than the broadcast. The following trials bear this out. Also a comparison is made of sprouted seeds sown broadcast on a well prepared puddled land.

Table VI.

Comparison of yield under different methods of cultivation (Cawnpore).

—	Grain	Straw
Transplanted	1,748	3,800
Broadcast	1,026	1,957
Sprouted seed on puddled land	1,330	2,983

Although transplantation shows the best return, yet the method cannot be adopted universally. There are various reasons for this, the most important being the situation of land and the supply of labour. In the absence of any artificial means of irrigation, transplantation is possible only in low lands which are able to hold water. Also the process being a slow and laborious one and requiring about a dozen labourers to transplant one acre in one day, it is difficult to transplant the whole available area where labour is scarce.

3. Loss from late sowing.

It is generally known that if the rains are late the rice crop is poor. To obtain some idea of the loss due to late transplanting and to gather information as to the relation between the time of sowing and the decrease of the crop, seedlings were transplanted at interval of ten days. The dates of transplanting are shown in the Table, but the sowing in the nursery in each case was done about a month and ten days before transplanting. The first sowing and transplanting were done at the usual time, *i.e.*, June 5th and July 15th, respectively.

Table VII.

The relation between the time of sowing and the yield.

Transplanted on	Doiwala		Cawnpore		Tulsipur		Average of the three places		Loss per cent.	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
July 15th . . .	1,615	2,090	1,767	3,648	1,990	4,237	1,757	3,325	0	0
July 25th . . .	1,425	1,919	1,710	3,515	1,957	4,180	1,691	3,211	4·3	3·4
August 4th . . .	1,197	1,748	1,577	2,964	1,862	3,819	1,539	2,850	12·9	14·2
August 14th . . .	1,140	1,615	1,425	2,508	1,748	3,135	1,444	2,594	18·2	28·0
August 24th . . .	912	1,235	1,349	2,090	1,520	1,489	1,254	1,938	29·0	41·7

A late ripening variety was sown at three places.

It is obvious from the above that the earlier the transplanting can be safely done, the better it is for securing a good outturn. The loss due to late sowing is greatest at Doiwala and least at Tulsipur. A delay of transplanting by about a month and a half beyond the usual time, *i.e.*, on 24th August, means a loss of 43 per cent. at Doiwala, 23 per cent. at Cawnpore and 20 per cent. at Tulsipur. The loss of straw in almost all cases exceeds the loss of grain. It is thus obvious that the prevail-

ing practice of transplanting earlier in Dehra-Dun and later in the *tarai* than in the central plains is correct.

Early preparation and early transplantation are a great security against the failure of the crop. It is always safe to keep the seed bed in a flourishing condition, by irrigation if possible, in June and transplanting can be commenced when the regular rainy season just sets in, *i.e.*, about the first or second week of July. If transplanting is put off till August owing to scanty rains, the result will be poor. In unusual years when the rains are late, preparations have to be delayed except in places where there are canals. In such a case it is advisable to sprout the seeds and sow them broadcast in well puddled land instead of transplanting them. This saves time, and time is of the greatest importance when the rainy season threatens to be a short one. In such a season it is advisable also to grow as much broadcast paddy as the higher lands can carry.

4. Age of the seedlings at the time of transplanting.

It is a common practice for the seedlings to be transplanted when they are about five to six weeks old. The following results show that seedlings younger than 40 days are less productive. Seedlings older than a month and a half develop a thick root system in the seed bed and, when transplanted, the growth is poor and the yield is reduced. It is advisable to crowd the seedlings to some extent in the seed-bed in order to check root development before transplanting.

Table VIII.

The relation between the age of the seedling and yield (Cawnpore).

Age of seedlings.	Grain	Straw
20 days old seedlings	1,121	2,413
30 days old seedlings	1,330	3,135
40 days old seedlings	1,444	3,306
50 days old seedlings	1,235	2,793

5. The number of seedlings to transplant in each hole.

The following results show that four seedlings do well at Doiwala, one seedling at Cawnpore and two to four seedlings at Tulsipur. Ex-

periments were also conducted with early and late ripening varieties with thickly and thinly sown seed beds at each place. Details are not recorded here as nothing definite was found. The results, however, showed that distance and the number of seedlings are correlated. Generally speaking, when close planting was practised, one seedling gave the largest outturn, with wide planting more seedlings were required. The optimum rate for seedlings seems different for different varieties and it varies in different parts of the province.

TABLE IX.

The relation between the number of seedlings in each hole and the yield.

Number of seedlings in each hole.	Doiwala		Cawnpore		Tulsipur	
	Grain	Straw	Grain	Straw	Grain	Straw
One seedling . . .	1,007	1,653	2,204	5,016	1,482	2,242
Two seedlings . . .	1,064	1,672	1,919	5,073	2,166	3,800
Three seedlings . . .	1,083	1,634	1,938	4,674	2,052	3,515
Four seedlings . . .	1,273	1,843	2,014	5,358	2,109	3,515
Six seedlings . . .	1,235	1,710	2,033	5,377	1,881	2,983

An early ripening variety was sown at Doiwala, one with intermediate time of ripening at Cawnpore and late ripening at Tulsipur.

The usual practice of the cultivators is to put a large number of seedlings in one hole. The number varies from 8 to 20, the greatest number being in the eastern parts of the province. Further investigation on this point is important as the reduction in the number of seedlings sown, will be greatly profitable as is apparent from the following quotation [1]:—

"In Godavari, Tanjore and other southern Districts the usual seed rate was about 100 to 150 lb. per acre and the bunches from 5 to 8 and even 16 plants were transplanted. By single seedling transplantation, the rate was reduced to 21 lb., resulting in a saving of about Rs. 3 an acre in seed alone, without affecting the outturn. This system has been very widely taken up in Tanjore and other southern Districts and it is estimated that the profit arising therefrom must be worth about 10 lacs of rupees a year."

[1] *Report of Progress of Agriculture in India*, 1913-14, p. 34.

6. The distance apart at which to transplant the seedlings.

The results in Table X show that distance of six inches gives the best result at Cawnpore and Tulsipur and 9 inches at Doiwala. The difference of growth between plants sown 6 inches and 9 inches apart is less as compared with those of plants sown 9 inches and one foot apart.

Table X.

Effect of different distances between seedlings on yield.

Distance apart	Doiwala		Cawnpore		Tulsipur	
	Grain	Straw	Grain	Straw	Grain	Straw
Three inches . . .	912	1,425	2,204	4,294	1,710	2,793
Six inches	1,045	1,634	2,489	5,339	2,736	4,503
Nine inches . . .	1,083	1,938	2,318	5,130	2,622	3,895
One foot	589	1,083	1,862	3,819	1,957	3,610

A late ripening variety was sown and two seedlings per hole were employed throughout.

Thick coarse varieties with abundance of leafy growth do better at a distance of 9 inches, while thin slender ones with less leaves do better when sown at a distance of 6 inches. Taking the province as a whole the cultivators generally transplant 6 inches apart, and the practice seems to be correct.

7. Seed selection.

It is important that the grain intended for sowing should possess high germinative power. Light grains which usually fail to germinate should be eliminated. Two methods were employed at the Cawnpore farm to discard the light grains. One was winnowing and the other floating them off in a strong solution (about 20 per cent.) of salt in water. The latter method proved more effective.

TABLE XI.

Result of different methods of seed selection (Cawnpore).

Seed sown	Grain	Straw
Winnowed seed	1,634	5,719
Unselected seed	1,349	2,793
Treated with salt solution	1,862	6,232

The matter has received little attention in the United Provinces, and since rice grains contain a fair percentage of light seeds, it is recommended that the salt solution method of eliminating the light grains be universally adopted.

8. CONSTANT IRRIGATION AND ALTERNATE DRYING.

The subject is closely connected with drainage and soil aeration and has been dealt with by many workers. A brief survey of literature, with special reference to rice, has been given by Chopra[1]. Experiments were conducted at the Botanical Farm, Cawnpore, to see the difference in growth and yield under constant irrigation and under alternate drying. The water was changed, once a week, in beds under the former condition while it was drained off every week and the plots were aerated for a day in the latter. The results obtained are in agreement with the view that draining of rice lands for proper growth of plant is necessary. The figures in Table XII show that there is more yield given by the drained plot than the one under constant irrigation, although the vegetative growth is greater in the latter. Also ripening under constant irrigation was late and irregular. Many of the grains were not well set and a good few ears were damaged by a stem borer.

TABLE XII.

Effect of constant irrigation and alternate drying on growth and yield.

Treatment	Grain	Straw
Crop under constant irrigation	1,710	4,826
Crop under alternate drying and irrigation . .	1,957	3,895

[1] Chopra, W. C.—*Report on Sone canals in Behar to study rice irrigation and rice cultivation*, P. W. D.—Irrigation Branch,—Punjab, 1922.

According to Sen,[1] it pays to drain off the fields in the *uttra nakshhatra* (14th of September to 28th of September) and to fill up again in *hatia nakshatra* (28th of September to 12th of October). The fact that rice is a water plant has caused most rice growers to underestimate the value of good drainage as an aid in producing a uniform ripening, maximum yield and a superior quality of grain. Good drainage is equally as essential for rice as for wheat and other field crops.

(C). MANURIAL EXPERIMENTS.

In the first place, manures on the whole are difficult to apply to vast areas of fields in which rice grows, although they are almost always applied to the nursery. Secondly the kind of manure to be applied depends upon its availability and cost. Chemical fertilizers and cakes of castor (*Ricinus communis* L.) and *neem* (*Azadirachta Indica* Juss) are relatively expensive and difficult to obtain. There is also a danger of these manures being washed away by floods and rains which usually accumulate on rice fields. Cattle dung supplies is also limited because of universal use of the cowdung for fuel. The only treatment which is practically possible in canal irrigated areas and where water is available, in these Provinces is that of green manuring. It is not only cheap but easy to apply. It is obtained by sowing about 60 lb. of *sannai* (*Crotolaria Juncea* L.) seed in an acre of rice field about the beginning of May and ploughing it in when the land is puddled for transplanting. After ploughing in the crop, the fields are filled with water and left for about ten days for the material to decompose. Afterwards they are again stirred with a *desi* plough for breaking and mixing up the material completely.

Experiments were conducted at three places chiefly with the idea of comparing the results of green manuring with those of a few important manures. These manures consisted of chemical fertilizers, an oilcake, farmyard manure, and a compost of night soil. Farmyard manure consisted of cattle dung and cow-byre sweepings stored for about a year without cover under ordinary field conditions. The material of night soil was supplied by Dr. Fowler of the Technological Institute, Cawnpore. The method of preparation of its compost consisted of fermenting together anaerobically the material with farm weeds, more or less after the Chinese fashion as explained by King[2]. Although these experiments have only been carried out in duplicate for two years and are therefore not so reliable as would be a number of trials spread over several years, yet certain deductions can be made as to the value of different class of

[1] Sen, J. N.—*A study in the assimilation of nutrients by the rice plant—Pusa Bull.* 65.

[2] King, F. H.—*Farmers of forty centuries.*

manures. Two varieties, an early *bansmati* and a late *kalasukhdas* were tried at three places. The figures are average of four trials of each variety. The size of plots was the same as in cultural experiments. The outturn is given in pounds per acre.

TABLE XIII.

Result of manurial experiments at Cawnpore.

Fertilizer	Rate per acre	BANSMATI		KALASUKHDAS	
		Grain	Straw	Grain	Straw
1. Superphosphate	140 lb.	1,121	3,021	1,881	4,199
2. Castor cake (*Ricinus communis*).	15 md.	1,634	4,199	2,641	4,750
3. Farmyard manure	100 md.	1,387	2,945	2,185	5,130
4. Unmanured	..	912	1,862	1,482	3,534
5. Ammonium sulphate	160 lb.	1,672	4,446	2,698	5,266
6. Compost of night soil	100 md.	1,425	3,496	2,128	5,453
7. Muriate of potash	120 lb.	1,026	2,489	1,349	4,142
8. * *Sannai* + castor cake	..	2,261	7,543	3,420	9,728
9 * *Sannai* + farmyard manure	..	2,071	6,688	3,173	9,652
10. Green-manured with *sannai*	60 lb. of seed sown	2,489	7,163	3,648	8,664
11. * *Sannai* + ammonium sulphate.	..	2,242	7,660	3,591	9,804

* *Sannai* was first ploughed under and the manures spread afterwards, the rate was the same as under ordinary condition. A maund is 82 lb.

It is evident from the yield shown in the above Table that ammonium sulphate is a valuable manure for rice and has given a large increase over the unmanured plot. Oil-cake is almost equally useful. Night soil compost, rich as it is in nitrogen, shows better result than the ordinary farmyard manure. Superphosphate and muriate of potash do not seem to be very useful manures for rice cultivation in this soil, although both give a small increase over the unmanured. The best yields of rice in these experiments were obtained not by the use of fertilizers but by growing the crop on green manured field. The data shows that the yields produced from the use of manures applied alone and in combination with *sannai* are less than the yields given when the crop is grown

with green manuring alone. The application of heavy nitrogenous manures like castor-cake and ammonium sulphate to a plot which was already green manured seemed superfluous. It resulted in greater vegetative growth but less yield. Also, the plants showed signs of being overmanured. The ripening was irregular and many ears were found empty. They lodged badly near harvest which resulted in shedding of grains. Thus it is safe to conclude from these trials that green manuring alone is enough for giving the maximum yield. According to Messrs. Harrison and Subramania Aiyer,[1] draining is important in order to get the maximum benefit of green manuring.

Besides increased yield there are various other advantages of green manuring. A green-manured soil becomes loose, friable, responds better to tillage and on preparation produces a more suitable seed-bed than the one in which no vegetable matter has been ploughed under. It is also useful in bringing weeds under control.

The upland valley.

The results at Doiwala slightly differ from those at Cawnpore. Green manuring has not given so good a result. This may be due to two probable reasons. Firstly, the Doiwala soil is richer in organic matter and more permeable than that of Cawnpore (Table III) and further addition of organic matter probably spoils the texture. Secondly, green manuring is not the same thing as adding a definite quantity of manurial matter. The amount is dependent upon the growth of the plant to be ploughed in and this will vary from season to season.

Table XIV.

Effect of different manures (Doiwala).

Fertilizers	*Bansmati*		*Kalasukhdas*	
	Grain	Straw	Grain	Straw
1. Superphosphate	1,330	2,698	437	3,116
2. Castor Cake	1,805	4,085	703	4,826
3. Farmyard manure	1,577	2,432	551	2,641
4. Unmanured	1,425	2,071	304	1,748
5. Ammonium sulphate	1,843	4,199	1,710	3,672
6. Muriate of potash	1,178	2,489	399	2,793
7. Green manured with *sannai*	1,615	2,641	608	3,268

The rate per acre of different manures was the same as at Cawnpore.

[1] Harrison, W. H. & Aiyer, S. P. A.—*Mem. Dept. Agri. India, Chem. Ser.*, vol. III, no. 3 and vol. IV, no. 1.

Two more deductions can be made from this Table. In the first place, early varieties do better here than the late kinds. The latter grow well in the beginning, as is seen by profuse production of vegetative growth, but due to the fall of temperature early in the season, the grains fail to set properly and the crop suffers. Secondly, *bansmati* without any addition of a manure does better in the upland valley than at Cawnpore. This is probably due to the presence of more food material both in the soil and the water (Tables III and IV) and better drainage.

The *Tarai*.

The result of different manures in this region almost resembles those at Cawnpore. *Sannai* gives more yield than all other manures except ammonium sulphate and the oil-cake. Great difficulty was, however, experienced in growing *sannai* in this area. During the first year it was sown before the rains with the well water. The crop got scortched due to hot winds and the growth was poor. In the second year, it was sown by the first fall of the rains but the crop was short at the time of ploughing in. The growth in either year was not satisfactory. In the absence of any artificial means of irrigation *sannai* can be grown on ploughed fields with the first shower in June and when turned under in July, its small growth even after a month will greatly help in opening the clayey soil of this region and making it permeable.

Table XV.

Effect of different manures at Tulsipur.

Manure	*Bansmati*		*Kalashuckdas*	
	Grain	Straw	Grain	Straw
1. Superphosphate	722	2,546	2,356	4,674
2. Castor cake	1,235	3,952	2,660	7,011
3. Farmyard manure . . .	950	2,698	2,432	4,522
4. Unmanured	646	1,805	1,938	4,503
5. Ammonium sulphate . . .	1,330	4,408	2,774	6,688
6. Muriate of potash	589	2,166	2,185	3,496
7. Green manured with *sannai* . .	1,102	4,522	2,508	5,453

The rate per acre of different manures was the same as at Cawnpore.

It is also evident that unlike Doiwala, the area suits the cultivation of late varieties; early varieties almost invariably get damaged by *gundhi* which is prevalent in these parts. Also, vegetative growth is greater here than elsewhere.

In conclusion, I have to express my indebtedness to Mr. A Howard, C.I.E., Director of the Plant Industry, Indore, for his kind help in reading the manuscript and suggesting improvements. Also my thanks are due to B. Baijanti Prashad, L. Ag., for help rendered in working up various figures in the text.

Summary.

1. Rice is the most widely cultivated crop in the United Provinces and occupies one-fifth of the net area cropped.

2. Two systems of cultivation are mainly practised—broadcasting for early and transplanting for late varieties. The proportion of early to late varieties is about 2 to 1.

3. Transplanted rice yield more than broadcasted rice.

4. Early ripening varieties suit the western districts; while late varieties do best in the eastern districts.

5. Wild rice occurs everywhere.

6. The chief enemy of rice is the rice-sapper *gundhi* (*Leptocoriasa varicornis* F.).

7. Ploughing the rice areas after the crop is removed and during the hot weather increases the yield and also reduces weeds and insect attacks.

8. The earlier the transplanting the higher the yield, particularly in the western districts.

9. The seedlings should be 10 days old when transplanted. The local custom of planting six inches apart has been found to be correct. The number of seedlings now planted in each hole can be materially reduced.

10. Constant irrigation tends to prolong vegetative growth and so interferes with maturation. Occasional drying is important and results in an increased yield of grain.

11. Green manuring with *sannai* (*Crotolaria Juncea* L.) proved to be the most effective of the manures used.

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