SYMPOSIUM ON MEASUREMENT OF AVAILABILITY OF NUTRIENTS FROM FODDERS, GRASSLANDS AND GRAZING

A symposium on "Measurement of Availability of Nutrients from Fodders, Grasslands and Grazing" was held on the 11th January, 1967, during the 20th Annual Conference of the Society at Waltair. Dr. N. D. Kehar[1] presided over the symposium. Extended summaries of remarks made by the speakers who participated in the symposium are given below against the topics on which they spoke.

BY SHRI V. N. AMBLE[2] : *Problems in Measurement of Availability of Nutrients from Fodders, Grasslands and Grazing.*

The problem of measuring the availability of nutrients for livestock from fodders, grasslands and grazing is extremely complex but at the same time rather important. From the surveys for the estimation of livestock products and practices of feeding and rearing of livestock conducted by the I.A.R.S. in different parts of the country, it is estimated that through the feeds and fodders fed in the stall to cattle and buffaloes on an average 107 gm. of digestible crude proteins (D.C.P.) and 2,060 gm. of total digestible nutrients (T.D.N.) are available per head per day. Four-fifths of the D.C.P. (protein ingested) and one-fifth of T.D.N. (energy available) come from green fodder. No objective estimate of the nutrients from grazing is available. According to the report of the Committee on human and animal nutrition set up by the I.C.M.R. and I.C.A.R. in 1952, 525 million tonnes of greens are available through cut grass and grazing. Subtracting from this the amount of cut grass made available to the livestock as estimated from the livestock products surveys, it is seen that grazing would provide on an average 91 gm. of D.C.P. and 422 gm. of T.D.N. per head per day, assuming that most of the available grazing goes to cattle and buffaloes. If these figures are included it will be seen that green fodders and grazing each provides about forty-five per cent of the total availability of D.C.P. and one-sixth of the availability of T.D.N.

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Considering first the cultivated fodders such as berseem, jowar, etc., for ascertaining the amount of a nutrient (such as protein expressed in terms of D.C.P.) available from a particular fodder, it will be necessary to have information on (*i*) area under the crop, (*ii*) the average yield per hectare, (*iii*) the nutrient content as determined by chemical analysis and (*iv*) the digestibility coefficient, *i.e.* the fraction of the nutrient intake which is digested. The product of these four quantities leads to the estimate of total nutrients from the fodder under consideration.

Patwari records do provide some information on the area under fodder crops. Since however the information has not been much utilised hitherto it might be necessary to investigate into the adequacy and accuracy of the records and arrange for a rationalised check on a sampling basis. Practically no information is available on the yield of fodder crops. The available figures of yield of fodders grown in livestock farms, mostly under conditions of irrigation and fertilization, can by no means be taken to represent the level of yield in the farmers' fields. It is necessary to develop a suitable sampling technique for this purpose. The problem is more complicated than in the case of food crops as a number of cuttings are taken in crops like berseem and in many cases the farmer harvests the fodder crop daily in patches to meet the needs of livestock.

As regards the nutrient content of the fodder crop, the available information on the chemical composition of common feeds and fodder has been compiled by K. C. Sen and S. N. Ray (1962). The regional animal nutrition centres of the I.C.A.R. are collecting data on the composition of less common feeds and fodders. It is seen from the bulletin of Sen and Ray that there is need for further study of samples of even common fodders from different places. The nutrient content of fodder not only varies with the stage of growth but exhibits a good deal of variation from sample to sample, as is exemplified by the following extracts from the bulletin.

Range of crude protein content of guinea grass (young stage) : 4.73 to 13.96

	Stage	*Centre*	*Volume of Cr. Protein*
Jowar	Young	Bangalore	8.91
		Punjab	5.21
	Prime	Bangalore	3.42 to 10.05 (AV. 7.75)
		Panjab	3.76
	Ripe	Bangalore	4.63
		Punjab	3.87

Again limited information is available re: digestibility coefficients there being usually only a single sample value reported for one feedstuff. It is desirable that facilities for nutrition research are created in the agricultural universities and state animal husbandry departments and that the nutritive values of common feeds and fodders based on adequate and representative samples are determined.

The problems relating to the measurement of nutrients available from grazing are far more complex. In the first instence there is need to assess the extent of area falling not only under 'permanent pastures and other grazing land' but also other categories such as culturable waste, other fallow lands, forests, etc., a portion of which is actually available to livestock for grazing. Secondly as regards the quantity of grazing available per unit area, estimation by harvesting randomly selected 'plots' or 'cuts' is complicated by the fact that the animal does not graze all that grows in the area. It exercises its own selective preference for different species of grasses. One remedy for this is to use the animal itself as an instrument for measuring the amount of nutrients available. The animal is allowed to graze in a given plot and allowed no other feed except a given amount of an indigestible colouring or chromogenic substance such as chromium oxide and samples of faeces voided are collected and analysed for the content of chromogen and the nutrient in question. From the former the total amount of outgo is determined and from the latter the total amount of nutrient voided is estimated. From a previously determined value of digestibility coefficient, the amount of intake of nutrients can be determined. This method is being tried in New Zealand and U.S.A. In India only a beginning is being made in the application of this method at one or two nutrition research centres.

The I.A.R.S. intends to take up a pilot investigation into this problem following a different approach which may not be as satisfactory but is operationally more feasible for large scale application. After suitable stratification of the villages in a district selected for the pilot study, it is proposed to select 40 villages with probability proportional to the bovine population and with replacement. In these villages, in addition to the collection of particulars of land utilisation from the Patwari records and the ascertainment through observation and enquiry as to the extent to which areas under various categories are available for grazing, herbage cutting experiments will be conducted. These will be done at monthly intervals throughout the

different seasons. Two types of such experiments will be adopted. In one, a large number (20) of small cuts 1m × 1m each will be made at random all over the selected grazing area in the morning before commencement of grazing for that day and an equal number of cuts taken randomly again in the evening after grazing. The hervesting will be done at the ground level with hand shears and studied for total yield, botanical composition and chemical content. The differences should lead to some idea of the amount of nutrients made available through grazing that day. The estimate would no doubt be subject to errors due to the variation in the intensity of grazing by the animals in addition to that in the herbage composition and productivity. In the second method, to be adopted in a subsample of 16 villages for reasons of economy, in each grazing area under study a plot of size 10m × 5m is proposed to be fenced off for a month to assess the potential amount of the herbage which can be had from the grazing area when free from interference by the animals for a month. One-fifth portion of each of the plots will be harvested in the beginning to ascertain the initial growth. Half the remaining portion will be harvested after one month. The remaining half will also be harvested after one month but after allowing the cattle to graze in it for one day to ascertain the differential utitisation of various species of grazing available. Fresh plots will be selected every month for taking cuts and fresh villages will be selected each season at random for estimation of yield rates. Such a pilot investigation is proposed to be taken up in Sehore district of Madhya Pradesh.

There is also the further problem of apportioning the total amount of nutrients available among different categories of livestock. For this on the one hand it will be necessary to estimate the proportion of grazing-days assignable to different livestock through observation in surveys. On the other hand it will be necessary to conduct experiments on the rate of intake through grazing of different species of livestock.

SHRI R. GIRI[3] : *Basic Data Needed*

The basic data required for measurement of animal nutrients available from fodder, grassland and grazing relate to area and yield-rate per unit area of fodder and grass obtained from lands of following categories :

(*a*) land sown with fodder crops and fodder grasses ;

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(*b*) land sown with grain crops which failed and were fed to cattle ;

(*c*) land sown with grain crops which were used as fodder because of low grain yields ;

(*d*) land under grain crops yielding stalk, husk, etc. ;

(*e*) permanent pastures and other grazing lands ;

(*f*) forests open for grazing ; and

(*g*) extent of grazing done on (*i*) fallows (*ii*) culturable wastelands (*iii*) miscellaneous tree crop groves, and (*iv*) barren and unculturable land.

Area Data Available and Improvements Required :

The areas under (*a*), (*d*), (*e*) and (*f*) are fairly reliably known. Sown area (*b*) which is harvested for fodder or is grazed at an early stage for reasons of poor growth due to drought, etc., remains recorded as area sown with grain crops in the basic village form. Area (*c*) sown with grain crops in which the crops fail to the extent that harvesting for grain yield is uneconomic and the crops are therefore harvested for fodder or are grazed, often remains recorded as area under grain crops. It is only in Punjab that figures of "failed" area are separately compiled. Necessary provisions in the basic and abstract village forms and in the instructions to compile these forms should make available the area figures of (*b*) and (*c*).

Grazing is practised to a varying extent on different types of uncultivated lands listed under (*g*). No attempt, however, seems to have been made to obtain any estimate of extent of grazing done on these lands. It is by no means easy. Suitable sampling and measurement techniques have to be evolved.

Concepts and Standard Classification :

The reliability of the data on area under permanent pastures and other grazing lands can further be improved by enforcing adoption by standard land-use classification according to the concepts accepted on all-India basis.

In Assam, the pasture occurring in settled land is included under "waste" but that on unsettled land is recorded separately as "reserved for grazing". The two combined would give the total area under permanent pasture and other grazing land provided the grazing area on settled land is shown separately.

In Maharashtra and Gujarat, the areas under pasture, miscellaneous tree crops and groves, culturable waste and resting and other

fallows in occupied (settled) land are all included under the broad class "fallow", while these areas lying in unoccupied Government land are not distinctly shown. In order to obtain correct figure for area under pasture, it is necessary to make provision to record it distinctly in the basic form and to obtain its total in the village-level area abstract. In these States, further, the land left for growing grass which is harvested and sold or kept for comsumption on farm, is treated as area under grasscrops, and not under pasture, the argument being that it has not been grazed like a pasture but has been kept like fields growing such fodder grasses as lucerne, berseem, etc. This analogy, however, does not seem to be correct in as much as no preparatory tillage, manuring, sowing, irrigation, etc., are practised in the case of land left for growing grass during the monsoon. Therefore, although for the revenue purposes such grass land may be recorded separately as area under grass crop in the basic form and in the village-level area abstract, it should be inclded under area under permanent pasture and other grazing land for the purposes of land utilisation statistics.

The pasture in Punjab, Himachal Pradesh and Delhi is not separately recorded in the basic form, but it is included under the broad class "land available for cultivation (mumkin) including unappropriated Government waste" which embraces all culturable land not actually cultivated, all grazing and other lands not included under forests, *viz.*, banjar jadid, banjar kadim and banjar kadim charagah.

It would appear that this broad category covers 4 standard land-use classes, *viz.* (*i*) permanent pasture and other grazing land, (*ii*) area under miscellaneous tree crops and groves, (*iii*) culturable waste, and (*iv*) old fallow. So far as the standard land-use class of permanent pasture and other grazing land is concerned, it should include only that part of this broad category which constitutes banjar kadim charagah and orher grazing lands, whether reserved as such or not and whether owned by village community or individual holders. It is necessary to obtain a separate total of area under pasture land in the basic village form of these States.

In Rajasthan, whereas the permanent pasture and other grazing land reserved by Government as *johars*, is separately recorded in the basic form, the pastures (birs) are included under the land classes as *banjar*, *i.e.*, fallow of 7 years and more. In order that the pasture area in Rajasthan is accurately known, the *banjar* land should be split up into culturable waste and *birs* or grass preserves and to the latter should be added the *johar* land.

Yield. Data Available and Improvements Needed

While in respect of area under fodders and grass and the area grazed, some data are already available and some more may be obtained with little more efforts, data on yield rates of fodder, grass, straw, stalk, husk, etc., are conspicuous by their almost complete absence. Only rough estimates of these have been attempted for the purpose of national income estimation.

Some sporadic estimates of yield of straw, stalk, etc., on the basis of agricultural and dairy farm data are also available, but they are not sufficient for estimation purposes. The estimates of these by-products can be built up without much additional cost and labour if their yields is a sub-sample of plots selected for crop-cutting experiments are obtained.

Sample surveys need to be conducted for evolving suitable sampling technique and method of measurement for estimation of grass and fodder yields. While sampling method for estimation of yield of fodder and grasses grown as field crops will be relatively easier to evolve, that in respect of grasslands and pastures and grazing land will require considerable research.

To sum up, the coverage and reliability of the data on area of fodders, grass and grazing land need to be improved through (*a*) suitable provisions in the basic and abstract village forms to record these areas, (*b*) adoption of standard land-use classification and uniform concepts and definitions in these forms and (*c*) sample surveys. These data on yield rates may be obtained by extending the scope of the present crop cutting surveys and by organising additional surveys for which sampling techniques need to be evolved.

DR. K A. SHANKARNARAYAN[4] : *Ecological Survey of the Grassland in India.*

Grasslands play a vital role in the prosperity of livestock industry. In India a substantial proportion of livestock population is sustained on forages obtained from natural grasslands. But the grasslands in this country have through centuries undergone a severe exploitation and have been reduced to a state of very low productivity. Planned management is called for to restore the grasslands to pristine productivity.

Successful grassland management is dependent upon an understanding of the relationship of soil vegetation, climate and physio-

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graphy with its dependent biotic life. Many factors influencing the soil resources (such as water, wind, topography) as well as those factors which have altered the climax vegetation cover (such as fire, logging, grazing) have acted to produce a complex pattern of distribution and composition. There is need for the fullest and most accurate information practicable to secure on the ecology of grasslands in connection with the use and administration of grasslands and related resources for such purposes as livestock production, watershed protection and other legitimate demands. It is for the purpose of obtaining these basic facts, analysing the various problems and from them developing a comprehensive plan for managing the grassland resource, that ecological surveys of grasslands or range inventories are conducted.

An outline of the plan adopted for such an ecological survey conducted under the aegis of the Indian Council of Agricultural Research during 1954-62 is described in what follows :

Procedure for Selection of Site : The primary objective of the survey was to recognise the major grassland covers of India. It was, therefore, clear that most vuluable information pointing out to the possible make up of potential grassland cover would be obtained only by the examination of undisturbed or lightly disturbed grassland sites.

Unit of Survey : The five agricultural regions of India recognised by the Indian Council of Agricultural Research were taken up as convenient basal units for the survey. Within each region individual States were taken as working units.

Selection of Site : The selection of sites in all the soil and climatic region was made in consultation with the State Departments of Agriculture, Forestry, Animal Husbandry, Community Projects and Military Farms. Wherever possible adjacent sites were selected for comparative purposes in relation to intensity of use and therefore, also the degree of regression. The several items of the survey and technique adopted on selected one acre plots were as follows :

A. *Floristic Composition* : A plant community is recognised principally by its floristic peculiarities and any variation in these reflects the events happening within the community. The study of floristic composition, was, therefore, given a thorough consideration. These studies were taken up in two stages :

1. *Listing of Species* : All the plant species occurring within the sampling plot of one acre were listed under four categories namely

perennial grasses; annual grasses; herbs other than grasses; and shrubs and trees.

2. *Composition*: The method followed in the study of composition was the field adaptation of the 'line interception method' (Canfield 1942) and called the 'pace transect method'.

The actual sampling procedure consisted of determining the base line of the one acre sampling plot. Sampling for composition was done on five imaginary lines at right angles to the base line. The first line was taken at a distance of 8 paces (20 ft.) from the starting point of the base line. Subsequent lines were taken each at an interval of 16 paces (40 ft.), so that the fifth line was situated at 8 paces (20 ft.) from the end of the base line. The total length of the base line was then 80 paces or 200 ft.

For sampling the vegetation the examiner paced along the transect line keeping in view a distant object such as a tree, rock, fence post, etc., for direction. Starting from the base line, the examiner recorded data at every fourth step by putting closely on previously marked line on the toe of his right foot, a loop $\frac{3}{4}''$ in diameter attached to a long wire or shaft. If the loop enclosed a living rooted part of a grass plant, a hit on vegtation was considered to have been secured and the gross species on which the hit was secured was recorded on the write-up sheet. Alternatively it was considered as a missed hit. In either cases a ten dot-X-system of counting was maintained for every sampling point for guiding the distance traversed. Each transect line was of 80 paces and excluding the two base lines provided a maximum of 20 hits. If effective hits are secured at all the sampling points on the five lines, a total of 100 hits would be secured. In actual practice some hits on some or all the sampling lines usually were missed. In order to complete the 100 effective hits additional transect lines were taken in between the original lines. The total hits on each grass species were counted to arrive at the percentage composition.

B. *Plant Cover for Density*: The method adopted for studying the plant cover in the present survey, was the 'square foot denstiy method' of Stewart and Hutchings (1932). The method consisted of taking circular plot of 100 sq. ft. with a circle of 5.64 ft. radius (5 feet, 7.8 inches). The unit of measure of density is a square-foot of ground completely covered with vegetation when viewed directly from above. This concept is developed by picking the plants on a plot and placing them within the squar-foot area marked on the ground such that they fully cover the ground without overcrowding. Such a concept is

developed for different species with varying growth forms. A well maintained lawn is an example of a 100% plants cover while a bare area represents the other extreme. Using this square-foot as a unit of measure, the examiner views the vegetation enclosed in the 100 sq. ft. area and shifts the vegetation mentally into one square-foot units. The total number of such units directly gives the percentage plant cover.

C. *Forage Production* : The already marked 10 density circles were used for this purpose. Depending upon the availability of time, either different species were cut and weighed separately or only the dominant species were cut and weighed separately and the rest cut and weighed together and grouped under the head 'Others'. While entering the forage production, notes were kept as to the stage of maturity in qualitative terms as green, semi-green, etc.

D. *Vigour Studies* : The characters studied mostly on principal perennial species were the height, maximum leaf length, length of seed stalk, number of tillers and the basal diameter. Ten plants of each species located within the 100 sq. ft. density circles were taken as far as possible, failing which random plants were selected from the one acre sampling plot. In the case of trailing forms, one rooted plant was taken for these studies.

E. *Succession Studies* : The inference method was adopted in the survey in which method various communities of a locality are examined, compared and arranged in sequence according to the order in which they appear to have given rise to one another. Detailed observations were taken on individual plants especially those which were dying and those which appeared in their places. These observations in the field together with comparison of study spots under similar environmental conditions but subjected to different degrees of use, gave data for constructing the picture of progressive and regressive changes in the major grasslands cover.

F. *Forest Types and Sub-Types* : The purpose of collecting information on Forest types and sub-types recognised by Champion was to study the relationships, if any, existing between the major grassland covers recognised by the grassland survey and the forest types recognised by Champion. The listing of plant species done at each site was used to determine the Forest types and sub-types associated with the site.

Soil Studies : In view of the intimate relationship of the soil and the plant community that occurs on it, the soil approach was broadly

kept in view during the Grassland survey. In addition to general morphological description of the soil including such items as parent material, relief, drainage, slope, stoniness, permeability, presence of salt or alkali and other ground water level, observations were taken on characters affecting the stability of the soil. The study of the plant cover or density, the litter and the erosion status reflect the degree of soil stability on a given site. General observations were taken on the accumulation, quality and quantity of litter on the sites studied. For assessing in the degree of erosion, notes were recorded on soil movement, pedestal formation, erosion pavement, rill, marks, gullies, soil deposits and trampling displacement.

In addition to the field observations, a sample of soil was generally taken to a depth of 9 inches for laboratory studies. These included such items as colour, texture, water holding capacity, soil reaction, total soluble salts, soluble potash and phosphate, carbonate, content and organic carbon content.

As a result of experience and data obtained during the survey, Dabadghao (1960) recognised five major types of grass covers in India, namely :

1. *Dichanthium-Cenchrus-Lasiurus cover.*
2. *Sehima nervosum-Dichanthium annulatum cover.*
3. *Pharagmites-Sccharum cover.*
4. *Themeda—Arundinella cover.*
5. *Temperate* and *Alpine grass Cover.*

Limitations : Being a rapid reconnainance survey with a prescribed time limit for its completion, the scope of the scheme was restricted to the detailed examination of a limited number of representative sites. This survey was of preliminary nature and provided information only on the broad grass covers of India although it offers a sound basis for more intensive work. In India we are faced with varied climatic, soil condition, history of land use and complex vegetation. Measurement of such a vegetation is, therefore, complicated and requires very extensive ground work. A prerogative, therefore, is to simplify the ground work. The use of aerial photograph can considerably help in this direction.

DR. B. M. PATEL[5] : *Measurement of Availability of Nutrients from Fodders, Grasslands and Grazing.*

Nutrition is one of the important factors influencing the general health and efficiency of livestock and hence measurements of avail-

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ability of nutrients from fodders from different sources are of utmost importance.

Different methods for the measurement of nutrients :—

(*a*) Measurment of dry matter (D.M.). This method would be applicable only when the two pastures with uniform species of pasture grasses and located in the same area *e.g.*, two pastures in Kutch or Saurashtra area, are to be compared.

For this purpose, depending upon the area of the grasslands suitable number of random samples each from 12 sq. ft. area are harvested.

(*b*) Measurement of chemical composition. If the grasses under the above conditions of the two pastures are different, or if the two pastures with similar species of grasses are located at distant places it is necessary to analyse the individual samples in duplicates for chemical composition because the composition of the grasses and fodders are found to vary due to several following factors.

1. Soil type and fertility.
2. Irrigation—Natural or Artificial.
3. Manures and fertilizers.
4. Type of grazing.
5. Quality of grass species.
6. Seasonal variation : Protein content of guinea grass is more and fibre is less in winter as compared to in summer and monsoon.
7. Variation due to cutting at different intervals or stages. Guinea grass was found to be best in terms of protein having best forage value when harvested between the pre-shooting and boot-leaf stages and subsequent monthly cutting intervals. Similar recent experiments on the effect of stage of cutting on napier hybrid and bajra indicated that (*i*) harvesting perennial napier hybrid at 50 days interval is desirable in terms of nutrients as well as money; (*ii*) the nutritive value of cereal straws depends upon the proper stage of harvesting. A delay in harvesting by 5 to 7 days of the bajra crop makes the fodder fibrous and also the loss of carotene which is a precursor of vitamin A occurs.
8. Association with legumes.

Legumes buildup soil fertility hence it is advantageous to introduce legume species in pasture and cultivate them. The

studies of growing lucerne in between the rows of guinea grass showed that the quantity of fodder is increased and also the quality is improved.

(*c*) Measurements of digestible nutrients. When the two fodders do not vary much in chemical composition they can be compared by carrying out the actual digestibility trial. Usually in such trials four to six animals are fed the measured amount of nutrients for a period of ten days (after a preliminary feeding period of 7 or 10 days) and on each day the feces voided by each animal is collected and analysed separately to measure the undigested nutrients and from the difference the digested nutrients are measured which gives more accurate measurements than by the previous methods.

(*d*) Metabolic trail. In certain fodders even the digestible nutrients may be similar; under such circumstances appropriate comparative measurements can be done by metabolic trials, *i.e.*, by noting to what extent the digestible nutrients are metabolised or useful in the body. This can be done along with the digestibility experiments in which urine samples of the animals are also separately collecled.

Such measurements of pasture grasses of Banni area of Kutch and Saurashtra (1954-'55) and of Hissar district in Punjab (1955-'56) indicated that mojority of grasses are of inferior quality and yields are also much less indicating the necessity and lot of scope for the improvement of existing pastures. The pastures in tropics are poor in quality compared with well managed pastures in temperate countries. The experiment conducted at Chharodi farm showed that the pasture grasses are poor in nutritive value and hence animals cannot be maintained only on grazing but must be provided with some concentrate.

Statisticians have an important role to play in this connection. They can collect data regarding the availability of nutrients from different regions of the country. This may include information on different crops which can supply fodder for cattle directly or indirectly. It may be a fodder specially cultivated, fodder from cereal crops or indirectly from vegetable crops. Period taken by each crop, nutrient availability and economics of different crops should be looked into. From this it should be possible to devise for different regions the optimum cropping pattern. While comparing vegetable crops like cabbage and brinjal they must consider the fodder availability from cabbage crop and assign that much extra value to this crop. Similarly

they can compare some of the cash crops like tobacco and groundnut.

Importance of such statistical data :

If the data of such measurements of nutrient yields from all the crops in each region or tract that can be grown in the same season is worked along with the economical return it would provide useful information to decide which crops should be grown. The following data would give some idea about its importance.

Dry matter and nutrient yields and net profit from different crops (yield in kg./hec.)

Crop	*Duration days*	*Dry matter*	*Protein*	*E. Extract*	*N.F.E.*	*Net profit Rs.*
Bajra	120	Fodder 7480 Grain 1920	257 246	128 138	3840 1470	900
Guar	120	Fodder 3614 Seeds 1075	382 300	54 25	1920 635	800
Tur	210	Fodder 2950 Seeds 924	295 184	136 18	1680 620	1000
Gabbage	120	Fodder 4950 Cobs 5080	550 1010	290 186	2950 1960	1900
Groundnut	120	Fodder 3200 Seeds 2000	394 420	93 920	1730 400	1800
Tobacco	210	1980	350	160	—	1250

If such data for each district in each state is worked out it could help in increasing the food production for human beings along with increase in the fodder prodution which would be most helpful in solving to some extent the critical shortage of food for the human population and the livestock.