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GROWTH PATTERN OF INDIAN IRON AND STEEL INDUSTRY
—*Dr. B. R. NIJHAWAN*

ROLE OF SCIENCE AND TECHNOLOGY IN INDIAN AGRICULTURE
—*Dr. M. S. RANDHAWA*

AGRICULTURAL PRODUCTION IN THE PAST DECADE AND ITS FUTURE PROSPECTS
—*P. C. RAHEJA*

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Growth Pattern of Indian Iron and Steel Industry

Dr. B. R. NIJHAWAN
Director, National Metallurgical Laboratory

The hard core of long-term planning in India as embodied in our successive Five Year Plans has been the establishment of "heavy" industry in its diverse phases including the growth of integrated iron and steel complexes and net work of small plants based on resources of men and materials, essentially indigenous. Whilst the capital outlay for the establishment of pillars of heavy industry and tandem growth of medium and light industries have followed certain characteristic pattern influenced by constraints imposed by our balance of payments and thereby based on friendly aid wherever possible, the reliance on capital fundamentally indigenous has been basic.

The main objectives of economic planning in India are to raise the standards of living of India's multitude, provision of adequate opportunities for the development of indigenous talent and economic industrial growth in the ultimate analyses, on "ones own legs". These short-term and long-range purposeful, sustained and titanic economic planning and growth have not been without the inevitable toil and sweat and problems arising in the maze of rapidly expanding horizons of research and technology, of technical education and mass literacy and deepening challenges of war against poverty within and a foe beyond. Such then is the broad-based spectrum of the ancient and modern India ; the ancient still standing true and majestic and the modern shimmering into industrial nationhood.

Modern Technology and Steel Production

The impact of modern technological developments in the metallurgy of iron and steel production, has been square and ever-lasting on Indian iron and steel industry. The metallurgy of iron and steel is based on processes that have essentially remained unaltered in essence over the past century but have undergone spectacular changes in the scale of operations and efficient processing of raw materials and "refining" techniques based essentially on contemporary developments in engineering technology. It is now well established that iron and steel are basic to heavy industrialisation in any country. The problems that confront India are complex relating chiefly to difficulties of foreign exchange, raising of productivity potential, shortage of technical trained personnel and insular shortages of indigenous capital goods and maintenance spares. In spite of vast good grade iron ore proved reserves of over 20,000 million tonnes, the heavy expansion of steel

* Pre-print of paper for Symposium on 'Science and the Nation during the Third Five Year Plan'.

industry has revealed some basic deficiencies in the raw materials ; high alumina contents and unfavourable Al_2O_3/SiO_2 ratio of Indian iron ores particularly in the ore fines aggravated by heavy monsoon rains, high ash contents of Indian metallurgical coals, shortage of steel-making quality limestone flux etc. are characteristic of the situation. The reserves of metallurgical coal are not only limited but also concentrated in Eastern India and generally have high ash contents that make their expensive washing "a must". The basic steel-making flux i.e. Indian limestones are exceedingly high in "insolubles", tending to change the "steel-making" into "slag-making" from a metallurgical "metaphor" to an undesirable reality. The conjoint ill-effects of such problems are obvious considered in the context that India's annual ingot-steel production capacity which is now being expanded from 6 million to about 9—10 million tonnes at the end of the Third Five Year Plan (1965-66), is further projected to yield at the end of the Fourth Five Year Plan (1970-71) an annual production of 18 million tonnes of ingot steel necessitating the establishment of a steel-making capacity of 20-21 million tonnes a year, thereby yielding 13.6—14 million tonnes of finished and rolled steel products. These developments have been planned on the basis that at no time during the Third and Fourth Five Year Plans is there any possibility of supplies exceeding demands, despite the current emphasis on exports. A demand of 6.9—7 million tonnes per year of rolled and finished steel products at the end of Third Five Year Plan (1965-66) has been established corresponding to over 9 million tonnes of annual ingot steel production to be achieved on the basis of the following break-up :—

Existing Steel Plants	*Million tonnes per year (ingot steel)*
Tata Iron & Steel Works	2.0
Indian Iron & Steel Works	1.0
Bhilai (Hindustan Steel Ltd.) (after current expansion in hand)	2.5
Rourkela (Hindustan Steel Ltd.) (after current expansion in hand)	1.8
Durgapur (Hindustan Steel Ltd.) (after current expansion in hand)	1.6
Miscellaneous small units	0.1
	9.0

The maximum actual output from the existing Plants and their current expansion plans under execution may yield 6.86—6.9 million tonnes per year of finished steel equivalent to over 9 million tonnes of ingot steel, provided the attainment of almost 100% production of the rated capacity, is physically achieved at the end of the Third Five Year Plan, which however in actual practice could be problematical. In these schemes, a million tonnes per year of ingot steel output from the projected Bokaro Steel Plant at the end of the Third Five Year Plan had to be excluded ; the Third Plan had originally been planned to yield an ingot steel production of over 10 million tonnes per year during 1965-66, subject of-course, to actual steel production and installed capacity fully matching each other. These Plans have now been supplemented by additional targets of about 6.75 million tonnes of rolled and finished steel to be accounted for at the end of the Fourth Five Year Plan (1970-71) corresponding to 8.8 million tonnes annually of ingot steel and adding up to a total of about 18 million tonnes of ingot steel per year, or about 13.6—14 million tonnes annually of finished rolled steel. These plans, formidable under Indian conditions of scanty capital goods, trained men and materials, yet dynamic judged by any yardstick, have to be fulfilled through expansion by the end of the Fourth Five Year Plan (1970-71) of production capacities on the following basis :—

Steel Plants	*Million tonnes/ year ingot steel*
Bhilai (Hindustan Steel Ltd.)	3.25
Durgapur (Hindustan Steel Ltd.)	3.0
Rourkela (Hindustan Steel Ltd.)	2.5
Tata Iron & Steel Works	3.0
Indian Iron & Steel Works	2.0
	13.75 m. tonnes capacity of ingot steel

Actual ingot steel production to be physically obtained from the above Plants during 1970-71 may however be somewhat less than 13.75 million tonnes. To the above total, may be added 3 million tonnes a year of ingot steel production from the projected Bokaro Steel Plant decidedly to be established on the basis that an annual capacity of 4 to 4.5 million tonnes of ingot steel production for Bokaro Steel Plant would possibly have been created by 1970-71. Additionally the South Indian Iron & Steel Plant based on the use of Salem magnetite and Neyveli lignite may be expected to yield 0.5 million tonnes of ingot steel annually during the Fourth Five Year Plan. Even apart from the South Indian Steel Plant, an annual ingot steel production of 16.75 m. tonnes has thus been planned. To meet however, the projected figure of 18 million tonnes a year of ingot steel production by 1970-71, additional steel capacity would need to be set up specifically more so, since to physically attain 18 million tonnes of ingot steel annual production, a production capacity fairly in excess thereof would be necessary on the premise that actual steel production and the rated capacity will not always and at least during the initial "teething" periods fully match each other. To meet these requirements, two additional Steel Plants at new locations currently under study would be established, each with an annual ingot steel capacity of 1.5 million tonnes ; this would give an annual total of 19.75 or say about 20 million tonnes of crude steel production capacity projected by 1970-71. In this connection, the Hindustan Steel have started survey of the Bailadilla (Madhya Pradesh)—Vishakapatnam belt whilst Government of India's noted Steel Consultants, Messrs. Dastur and Company are likewise actively surveying the Bellary (Andhra Pradesh)—Hospet (Mysore) belt and Goa Coastal area, for future Steel Plants to be set up during the Fourth Five Year Plan. These steel plants though designed for an initial annual production of 1.5 million tonnes of ingot steel by the end of the Fourth Five Year Plan, would also be capable of expansion to an annual capacity in each case of 3—4 million tonnes of crude steel. The establishment and growth of coastal plants, such as at Goa may also favourably consider the import of high grade metallurgical coking coal or coke to be balanced against the export of iron ore pellets made out of beneficiated iron ore fines from Goa mines at a price of about 12 dollars a tonne. It is a welcome feature of current Indian planning that the establishment of new Steel Plants is distinctly more "raw-materials oriented" rather than solely "equipment-oriented". Among the items to be produced in these Steel Plants, the flat products would predominate, since the deficit is particularly noticeable in diverse flat products. The magnitude of planning and scale of operations, it would be appreciated, are truly titanic, more so when the production has to be systematically rationalised and oriented to optimum end-product mix based on advance yet comprehensive market surveys. Current thinking also favours the building up of stocks of say 1—1.5 million tonnes of steel by 1970-71 to withstand the strains of war and stresses of peace ; such planning is in conformity with the rationale of India's accelerated steel development plans so that India can, not only hope eventually to become the "Workshop of the East" linking her exports of multitude end-products with assured physical supplies of home-made steel but would also attempt to regain the position she once had as the cheapest steel producer in the World.

Ambitious Planning and the Problems

Before however, these plans can physically mature, complicated and difficult problems will have to be tackled, such as breaking new grounds in respect of raw-materials' bases and their speedy development following the now well-established criterion that the raw-materials will need optimum processing and sizing and possibly additional economic beneficiation treatments. The physical transport of raw materials by rail is one of the most formidable problems which can seriously stand in the way of economic planning particularly in attaining steel production targets. The shortage of technically trained man-power, skilled artisans and competent supervisory managerial personnel completes the picture, particularly when it is realized that the period of useful technical training can only be abridged marginally considered on the basis of its ultimate utility. These then are some of India's steel hopes and ambitions, physical difficulties and chronic shortages, which however unsurmountable at first sight, would need to be and are being effectively met and overcome as challenges to Indian ingenuity and skill. The serious intensity of the entire forward planning and current problems would be judged from the position that production of finished steel during 1962-63 was 3.9 million tonnes, a 100,000 tonnes less than the target. The 4.3 million tonnes target for 1963-64 may however, be achieved whilst production targets for subsequent years would suffer due to the delay in putting up the Bokaro Steel Plant—for instance, the target for 6.8 m. tonnes of finished steel for 1965-66 would be reduced by 900,000 tonnes owing to delay in putting up the projected Bokaro Steel Plant.

In the ultimate analysis, there may also be some adjustments necessary, such as possible doubling up of Durgapur Steel Plant's annual capacity from 1.6 million tonnes of crude steel to 3.2 million tonnes by the end of the Fourth Five Year Plan. It is also planned that Bokaro Steel Plant will be initially designed for an ultimate annual production capacity of 4 to 4.5 million tonnes and may attain an operational capacity of 3 million tonnes per year by the end of the Fourth Five Year Plan—to this could be added at least 1.5 million tonnes/year from each of two proposed Steel Plants to be set up during the Fourth Five Year Plan, whilst the maximum planned capacity of these two new Steel Plants, other than the Bokaro Plant, would be 4 million tonnes per year of crude steel in each case.

Whilst the foregoing reviews the planning data, the role of research and development themes in Indian steel industry including long-ranged study of Indian raw-materials for their exploitation by techniques conventional or hitherto unknown, imposes additional yet welcome responsibilities on indigenous research talent—these aspects of advance planning are being effectively handled at the National Metallurgical Laboratory in the fields of raw-materials' beneficiation and processing, burden preparations based on sizing, classification, agglomeration and sintering etc. in relation to conventional and alternative iron and steel production techniques that are to-day the symbols of increased productivity and lowered operational and production costs.

Figures 1 and 2 (*pages 6 and 8*) show the map of India indicating the principal iron and steel production centres and resources of raw materials including projected Steel Plants as also the projected Alloy Steel Plants etc.

It would be only right to realistically introduce an urgent element of "realism" in the execution of our long range and short-term Steel Plants based on closest possible co-ordination and urgent sense of responsibility at all levels of Projects' planning and their implementation ; it is however, not always so easy in fast developing countries, such as India wherein the multiple planned demands of a free human society are enormous indeed in their scope and still more so in their effective implementation. And yet the challenge must be met, clear and square by the free Indian Society.

Foundry Pig Iron

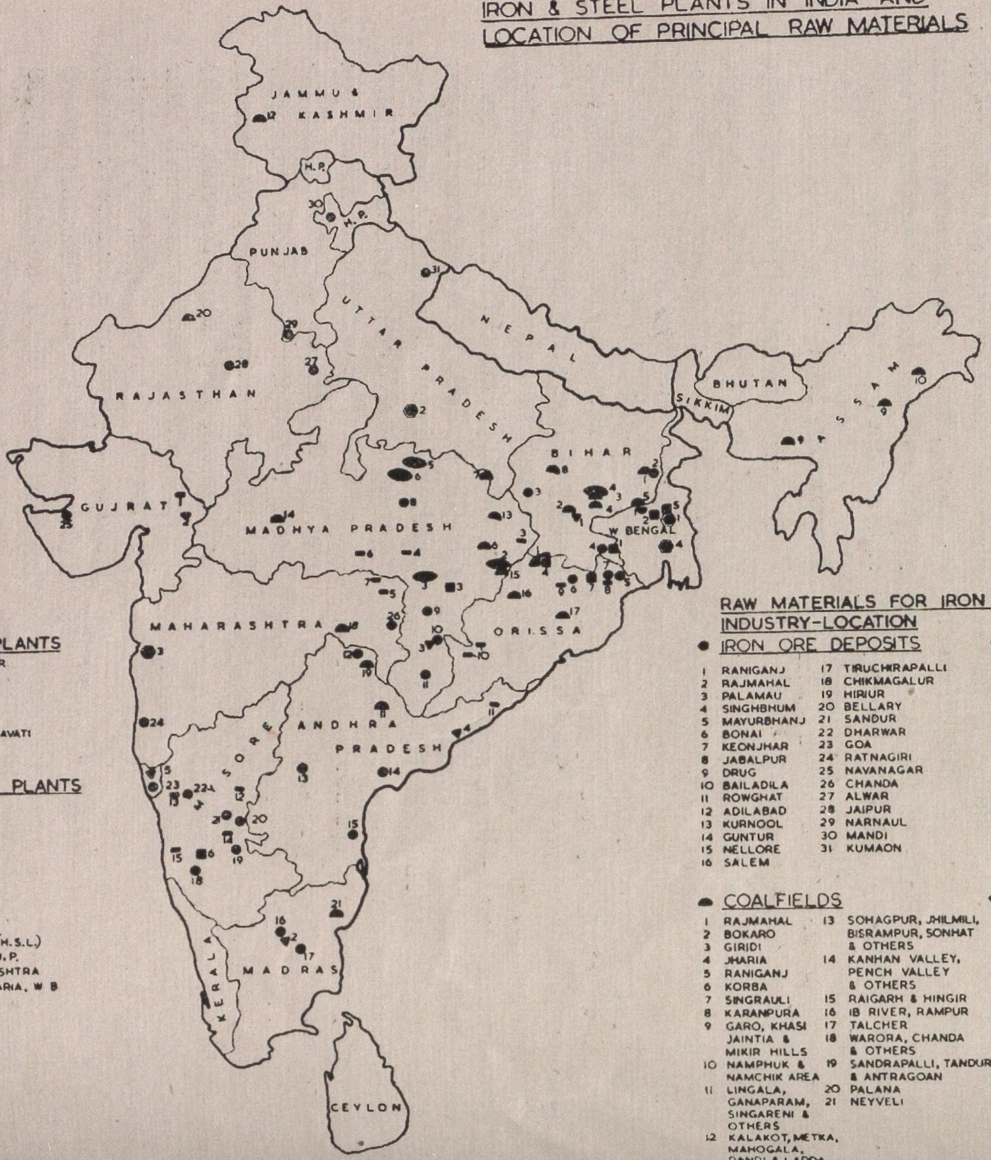
The current annual availability of foundry grades of pig iron is estimated at 1.1 million tonnes whilst the approximate present demand as estimated by trade bodies is of the order of 2.5 million tonnes per year—an earlier estimate of 2.0 million tonnes of foundry pig iron per year is based on 1.1 million tonnes for centrally listed foundries and 0.9 million tonnes for State list foundries. The available 1.1 million tonnes a year foundry pig iron is distributed in the following order : Steel Works maintenance 100,000 tonnes, railway sleepers 300,000 tonnes, spun pipe 187,000 tonnes, direct ordnance demands 60,000 tonnes, export promotion 50,000 tonnes, castings needed by Directorate-General, Supplies and Disposals 30,000 tonnes, railway maintenance and other Government departments 50,000 tonnes, foundries engaged on Ordnance contracts 20,000 tonnes, Central list foundries 176,000 tonnes and State listed foundries 120,000 tonnes and reserve stock 7000 tonnes.

Estimate and Planning

Whilst estimates made by different Indian industrial and trade bodies for total current requirements of foundry grades of pig iron and those projected at the end of the Third

IRON & STEEL PLANTS IN INDIA AND LOCATION OF PRINCIPAL RAW MATERIALS

Fig. 1



EXISTING IRON & STEEL PLANTS

1 TATA IRON & STEEL CO., JAMSHEDPUR
2 INDIAN IRON & STEEL CO., BURNPUR
3 BHILAI STEEL PLANT. (H.S.L.)
4 ROURKELA STEEL PLANT (H.S L.)
5 DURGAPUR STEEL PLANT. (H.S L.)
6 MYSORE IRON & STEEL WORKS, BHADRAVATI
7 KALINGA INDUSTRIES, BARBIL

PROJECTED IRON & STEEL PLANTS

STEEL PLANTS

1 BOKARO (H.S.L)
2 SALEM
3 BAILADILA, M.P.
4 VISAKHAPATNAM
5 GOA

ALLOY STEEL PLANTS

1 ALLOY STEELS PROJECT. DURGAPUR. (H.S.L.)
2 BAGLA ALLOY STEEL LTD., KANPUR, U.P.
3 MAHINDRA UGINES, KHAPOLI, MAHARASHTRA
4 TEXTILE MACHINERY CORPN., BELGHARIA, W B

RAW MATERIALS FOR IRON & STEEL INDUSTRY-LOCATION

IRON ORE DEPOSITS

1 RANIGANJ
2 RAJMAHAL
3 PALAMAU
4 SINGHBHUM
5 MAYURBHANJ
6 BONAI
7 KEONJHAR
8 JABALPUR
9 DRUG
10 BAILADILA
11 ROWGHAT
12 ADILABAD
13 KURNOOL
14 GUNTUR
15 NELLORE
16 SALEM
17 TIRUCHIRAPALLI
18 CHIKMAGALUR
19 HIRIUR
20 BELLARY
21 SANDUR
22 DHARWAR
23 GOA
24 RATNAGIRI
25 NAVANAGAR
26 CHANDA
27 ALWAR
28 JAIPUR
29 NARNAUL
30 MANDI
31 KUMAON

MANGANESE ORE DEPOSITS

1 PANCH MAHALS
2 BARODA
3 GHORIAJOR BAMRA
4 BALAGHAT
5 BHANDARA
6 CHHINDWARA
7 NAGPUR
8 KEONJHAR
9 BONAI
10 BHAWANIPATNA (KALAHANDI)
11 SRIKAKULAM
12 SANDUR
13 NORTH KANARA
14 CHITALDRUG
15 SHIMOGA

COALFIELDS

1 RAJMAHAL
2 BOKARO
3 GIRIDI
4 JHARIA
5 RANIGANJ
6 KORBA
7 SINGRAULI
8 KARANPURA
9 GARO, KHASI JAINTIA & MIKIR HILLS
10 NAMPHUK & NAMCHIK AREA
11 LINGALA, GANAPARAM, SINGARENI & OTHERS
12 KALAKOT, METKA, MAHOGALA, DANDI & LADDA
13 SOHAGPUR, JHILMILI, BISRAMPUR, SONHAT & OTHERS
14 KANHAN VALLEY, PENCH VALLEY & OTHERS
15 RAIGARH & HINGIR
16 IB RIVER, RAMPUR
17 TALCHER
18 WARORA, CHANDA & OTHERS
19 SANDRAPALLI, TANDUR & ANTRAGOAN
20 PALANA
21 NEYVELI

LIMESTONE QUARRIES

1 BIRMITRAPUR
2 HATIBARI
3 NANDINI
4 BHAWANATHPUR
5 SATNA
6 KATNI

and Fourth Five Year Plans somewhat differ, it has been generally accepted that by the end of the Third Five Year Plan, the demand would be over 2.006 million tonnes per year and 3.462 to 4 million tonnes per year by the end of the Fourth Five Year Plan whilst the annual established capacity of foundry grade pig iron at the end of the Third Five Year Plan may not exceed 1.5—1.75 million tonnes thereby making it imperative to raise an additional capacity of over 2 million tonnes per year of foundry iron chiefly during the Fourth Five Year Plan. The production capacity expected by the end of the Third Five Year Plan would be based on supplies from the existing plants and the small foundry iron plants for which several industrial licences have already been granted to account for 0.6—0.8 million tonnes annual output, if all the licences are actually operated during the period ; this would however, mean that an additional annual capacity of 2 million tonnes of foundry grades of iron would need to be established by the end of the Fourth Five Year Plan. The heavy shortfalls in foundry iron production figures today and during consecutive Plan periods provide enough food for thought and action and a challenge indeed to be met. Whilst it may be that this shortfall has been inherited from one Plan to other, it is however, most necessary for us to break away from this "heritage". The estimate of 3.5 million tonnes of foundry iron made by National Council of Applied Economic Research for the end of the Fourth Five Year Plan is however, now recognized as low and plans are underway to establish a capacity of 4 million tonnes of foundry iron annual output by 1970-71. The National Council of Applied Economic Research estimates are based on the following.*

	Estimated Requirements (tonnes)	
	1965-66	*1970-71*
1. Pig Iron for iron castings including steel pipe fittings	1,377,000	2,232,900
2. Pig Iron for cast iron pipes and specials	628,900	1,229,000
Total	2,005,900	3,461,900

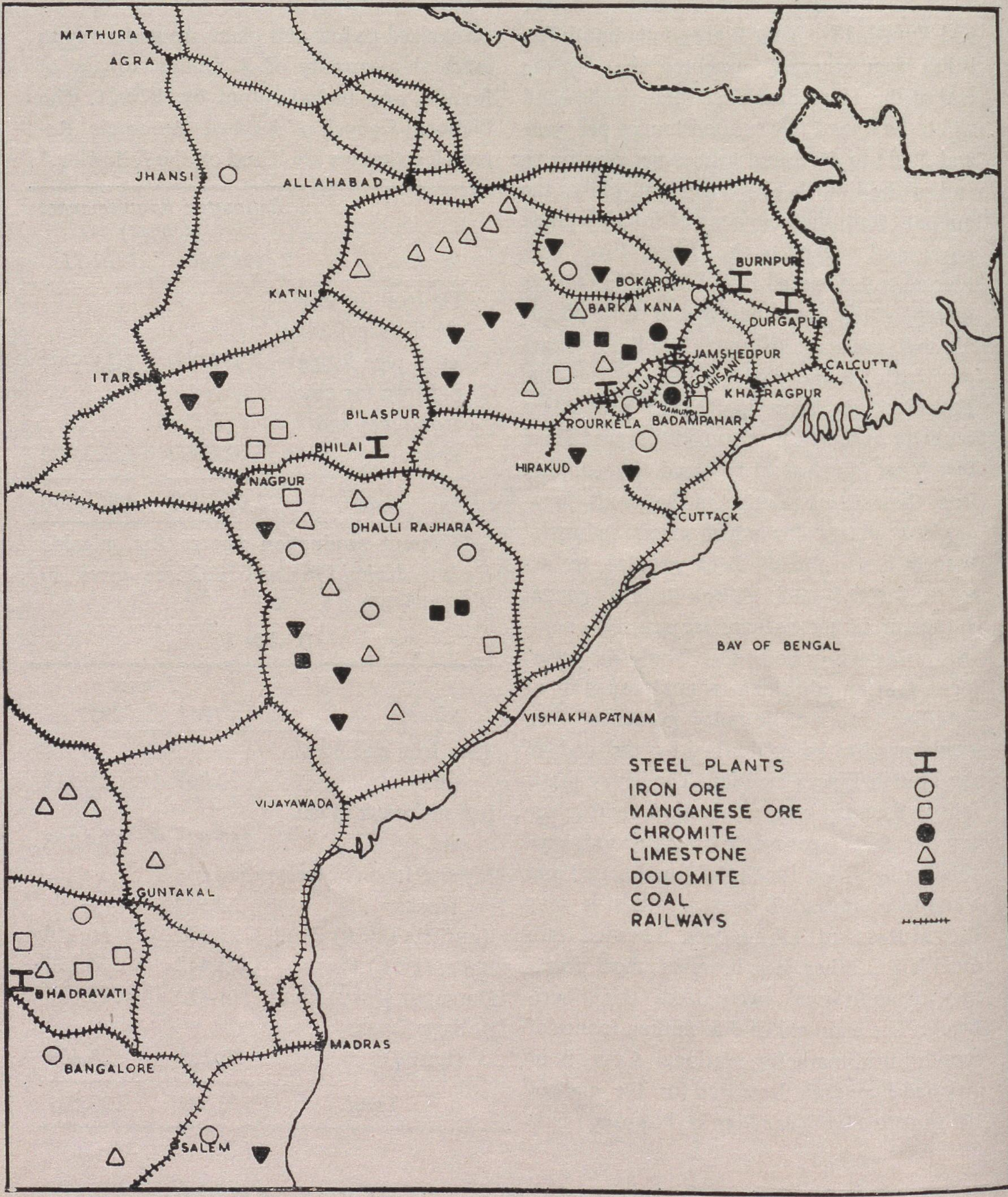
Current production figures for saleable pig iron during 1961 and 1962 are given in the Table No. 1†.

Table 1

	Tonnes	
Plant	*1961*	*1962*
Tata Iron and Steel Co.	20,868	21,112
Indian Iron & Steel Co.	267,873	204,298
Mysore Iron & Steel Works	9,934	—
Rourkela (HSL) Plant	99,370	60,246
Bhilai (HSL) Plant	393,442	334,390
Durgapur (HSL) Plant	314,792	325,016
Kalinga Works (Barbil)	30,255	28,469
Total	1,136,534	973,531

* Reappraisal of Steel Demand, Vol. I, 1963. National Council of Applied Economic Research, New Delhi.

† Annual Report of the Ministry of Steel and Heavy Industries, 1962-63, Dept. of Iron and Steel.



MATHURA
AGRA
JHANSI
ALLAHABAD
KATNI
ITARSI
BILASPUR
BHILAI
NAGPUR
DHALLI RAJHARA
BOKARO
BARKA KANA
BURNPUR
DURGAPUR
JAMSHEDPUR
CALCUTTA
KHARAGPUR
ROURKELA
BADAMPAHAR
GUA
HIRAKUD
CUTTACK
BAY OF BENGAL
VISHAKHAPATNAM
VIJAYAWADA
GUNTAKAL
BHADRAVATI
MADRAS
BANGALORE
SALEM
STEEL PLANTS
IRON ORE
MANGANESE ORE
CHROMITE
LIMESTONE
DOLOMITE
COAL
RAILWAYS

Fig. 2

Alloy, tool, special and stainless steels

Looking retrospectively back at the First Five Year Plan, one would no doubt notice the rather lukewarm approach towards the establishment of alloy, tool, special and stainless steel industry in India—the plans for the alloy and special steels production targets were hardly in forefront. Some half-hearted measures designed to promote the special and alloy steel industry were discussed at different platforms. It was almost indeed at the end of the First Five Year Plan that the National Metallurgical Laboratory organised an international Symposium on "Production, properties and applications of alloy and special steels" in February 1956 which succeeded in arousing the interests of those concerned towards the static state of alloy and special steel's industry in India then even on the planning and blue-print boards. It was at the above international National Metallurgical Laboratory Symposium that the author had put forth planned estimates for the alloy and special steels targets emphasizing that the minimum requirements of the special and alloy steels in relation to 10 million tonnes of mild and plain carbon rolled and structural steels per year would be at the very minimum 0.5 million tonnes and could be much more in relation to economic development plans for the Second Five Year Plan. It was then argued at this Symposium that if India were to take her rightful place in the comity of nations as a modern powerful and heavily industrialized Republic as justified by her mineral potential and resources, it was appropriate to plan on the higher side of the estimates. It should not be overlooked that India can be potential exporter of alloy and special steels to South Eastern countries, East Asian and Far-Eastern countries, where such specialized products should prove valuable bargaining counters for the import of mineral resources and material products in which India is so short. As such, an annual target of a million tonnes of alloy, tool, special and stainless steels at the end of the Third and at the start of the Fourth Five Year Plans was then projected by the author early in 1956 ; the position that those estimates were indeed realistic would be borne out by the target figures now projected and accepted by the N.C.A.E.R. and other authorities engaged in planning and in executing the approved plans. At the end of the Fourth Five Year Plan, a production target of 18-20 million tonnes of non-alloy steels is to be attained ; the corresponding annual target for alloy, tool, special and stainless steels would be 1.8 to 2 million tonnes and even these estimates may prove to be somewhat on the lower side for the highly specialized and indispensable requirements of the industrial era to come.

Table 2 gives a break-up of the alloy, tools, special and stainless steels estimates at the end of Fourth Five Year Plan, which form the basis of current planning.

If the production of low alloy high strength steels is planned on integrated steelworks and not classified as special and alloy steels for the purpose of above estimates, the targets for alloy, tool, special and stainless steels to be established by the end of the Fourth Five Year Plan would be 930,000 tonnes of annual finished alloy steel output, equivalent to 1.55 million tonnes of ingot alloy steel output per year.

Table 2

	Finished steel per year (tonnes)
(a) Alloy constructional Steel	250,000
(b) Stainless and heat resisting steels	80,000
(c) Electrical steel sheets	180,000
(d) High speed steel, tool steel and die steel	86,000
(e) Spring steel	134,000
(f) Free cutting steel	200,000
(g) Low alloy high strength steels	200,000
	1,130,000 tonnes

(or say 1,130,000 corresponding to annual ingot production of 1.89 million tonnes).

At the Durgapur Alloy Steel Plant of the Hindustan Steel Limited established by Government of India, in the initial phase, 14,500 tonnes of tool steel, 25,000 tonnes of constructional steel, 18,000 tonnes of stainless and heat resisting steel and 2,500 tonnes of other alloy steels—giving a total of 60,000 tonnes of finished steel, corresponding to a total of 100,000 tonnes of ingot alloy steels would be produced annually. Durgapur Alloy Steel Plant would ultimately be expanded to 300,000 tonnes per year when the product-mix would be 25,000 tonnes of tool steel, 75,000 tonnes of constructional steels, 60,000 tonnes of stainless steels mainly in sheet form and 20,000 tonnes of other special steels, giving an annual total of 180,000 tonnes of finished alloy steel production. The production of substitute alloy, tool and stainless steels based on indigenous alloying elements will also be taken up at some of the alloy steel plants, such as of the nickel-free austenitic stainless steels developed at the National Metallurgical Laboratory and other substitute compositions like 202 stainless series etc. Likewise, research and development themes on substitute tool steels, creep resistant alloys etc., are actively being pursued at the National Metallurgical Laboratory for industrial scale implementation in due course.

Total tonnage of alloy steels for which Industrial Licences have been granted by the Government of India would amount to about 0.47 million tonnes output a year at present as shown in Table 3.

Mysore Iron and Steel Works at Bhadravati currently under conversion to an integrated Alloy Steel Plant would annually produce about 77,000 tonnes of finished alloy constructional steels. It was early in 1963 that the proposal to convert the Bhadravati Plant into an integrated alloy and steel plant was accepted. Messrs Demag have proposed a three phase scheme for conversion of Bhadravati Plant ; in the first phase the plant will annually produce 42,000 tons of alloy steels and 38,000 tons of mild and structural steels. In the second phase, the total annual output of 77,000 tons would be of alloy steels. An additional 36,000 tons of mild steel will be produced in the plant annually during the third phase of conversion and expansion projected with technical collaboration of Messrs. Bohler of Austria. The main production will be of alloy constructional steels and spring steels. The total estimated cost for this plant is about Rs. 17

TABLE 3

LICENCED SCHEMES FOR ALLOY AND SPECIAL STEEL PRODUCTION

(in thousands of tons of finished alloy steels)

	Spring steel	*Free cutting steel*	*High speed tool and die steel*	*Alloy cons. steel*	*Stainless steel*	*Elect. steel*	*Total*	*Remarks*
1. TISCO, Jamshedpur.	—	—	—	—	—	80	80	4th Plan scheme.
2. H. S. L., Rourkela.	—	—	—	—	—	50	50	Under construction.
3. Globe Motors, Ballabhgarh, Punjab.	6	—	—	—	—	—	6	In production.
4. Canara Workshops, Nagpur.	9.6	—	—	—	—	—	9.6	Under construction.
5. Guest, Keen Williams Ltd., Calcutta.	45	—	—	—	—	—	45	Being extended in 2 stages, 30 000 tons expected by 1967-68.
6. Mahindra & Mahindra, Bombay.	—	—	—	18	—	—	18	Completion by 1966-67.
7. I. N. Pai, Bombay.	—	—	0.3	0.3	—	—	0.6	Completion by 1967-68.
8. V. Pandurangiah, Madras.	—	1	6	—	7	—	14	Completion by 1967-68.
9. D. Balasundaram, Salem.	—	—	2	8	—	—	10	Licenced for 50.000 tons including 13.000 tons of castings; to complete 10.000 tons by 1967-68.
10. Texmaco, Calcutta.	—	—	—	25	—	—	25	15,000 tons expected by 1967-68.
11. S. Baijnath, Kanpur.	—	—	—	19.8	—	—	19.8	Completion by 1967-68.
12. V. H. Shah, Ahmedabad.	—	—	—	—	20	—	20	... ..
13. K. T. Rolling Mills, Bombay.	—	—	3.4	5	—	—	8.4	Cleared for capital goods, completion by 1967-68.
14. Man Ind. Corpn., Jaipur.	24	—	—	—	—	—	24	—do—
15. MISW, Bhadravati.	—	30	12.3	31.7	—	—	74	Completion by 1967-68.
16. Hindustan Alloy Steels Project, Durgapur.	—	—	14.5	27.5	18	—	60	—do—
TOTAL	**84.6**	**31**	**38.5**	**135.3**	**45**	**130**	**464.4**	

crores. The erection of the Durgapur Alloy Steel Plant is now making good progress and with the supply of equipment from a Japanese consortium of firms, a small part is scheduled to go into production in October, 1964, when a 10 tons' furnace, a part of the forge shop, some of the maintenance facilities etc. would be completed. In the case of Private sector, amongst the licences issued in 1959, three alloy steel plants started erection in 1963, while another five had received licences for import of equipment during last year. Mahindra & Mahindra of Bombay (15,000 tons licensed capacity) and Bagla Project in Kanpur (20,000 tons licensed capacity) have obtained French technical assistance. The third project, well underway, of 7,000 tons annual capacity is at Madras. Even so, it is evident that output in 1965-66 will be far short of the targets, as most of the proposed plants will be in production only by 1967-68. In order to meet some of the urgent special steels' requirements, the Bhilai Steel Plant of Hindustan Steel Limited is likely to produce 150,000 to 200,000 tonnes a year of special steels covering some 41 categories of steels.

N.C.A.E.R. Estimates

The NCAER's annual estimate of demands for tool, alloy and special steels is 0.96 million tonnes ; the Steering Group rounded this figure to a million tonnes. The general plans now accepted after taking into account different estimates prepared by different bodies including the National Metallurgical Laboratory, cover the following :—

(i) The annual demand for finished alloy steels, including low alloy high strength and electrical steels, was likely to be 1.03 million tonnes against 0.96 million tonnes estimated by the NCAER. The estimates made by the NCAER and the Steering Group are compared in Table 4.

Table 4

	Finished Alloy Steels	
	NCAER's estimate (*tonnes*)	*Committee's estimate*
(a) Alloy constructional steels	200,000	250,000
(b) Stainless and heat-resisting steels	80,000	80,000
(c) Electrical steel sheets	176,400	180,000
(d) High speed steel, tool steel and die steel	86,100	86,000
(e) Low alloy high strength steel	100,000	100,000
(f) Spring steel	132,900	133,000
(g) Free-cutting steel	116,000	200,000
		1,029,000
	891,400	
Stocks (1/12 of total)	74,300	—
	965,700	1,029,000 or say 1,030,000

(ii) Of the estimated annual demand of finished alloy steels of 1.03 million tonnes, 100,000 tonnes of low alloy high strength steel and 180,000 tonnes of electrical steel are "tonnage" steels which may well be planned for production in the larger integrated steel-works ; which would leave a net demand of 749,000 tonnes per year.

(iii) Studying the possibilities of production in existing plants, including the Durgapur Alloy Steel Plant of the Govt. of India, the Mysore Iron & Steel Works, Bhadravati, and other units licensed in the private sector, it has been estimated that the production by 1970-71 would be about 334,400 tonnes ; the demand, production and deficits during the same period are indicated in Table 5.

Table 5

	Finished Alloy Steels		
	Estimated demand	*Production from licensed schemes*	*Deficit*
A. Main Producers, Mysore Iron & Steel Works and some Special Steel Plants :			
(a) Alloy and other machinery constructional steels such as En 8, En 16, En 18, En 32, etc.	200,000	100,000	100,000
(b) High carbon and silico-manganese spring steels	103,000	60,000	43,000
(c) Free-cutting steels	200,000	31,000	169,000
	503,000	191,000	312,000
B. Special Steel Plants including Durgapur Alloy Steel Project and Mysore Iron & Steel Works :			
(a) High speed, tool and alloy steels including ball-bearing steels, high carbon high chromium steels, magnet steels, etc.	86,000	38,500	47,500
(b) Stainless and heat-resisting steels	80,000	45,000	35,000
(c) Alloy spring steels, such as En 47, En 50	30,000	20,600	9,400
(d) High alloy constructional steels such as En 21, En 23, En 24, En 28, En 33, En 40, etc.	50,000	39,300	10,700
	246,000	143,400	102,600
Grand Total	749,000	334,400	414,600

Ferro-alloys :

Estimates of demands of ferro-alloys have been drawn up on the basis of requirements for plain carbon mild and structural steels and separately for alloy, tool, special and stainless steels ; so far as the requirements for the former are concerned, these would relate chiefly to non-manganese and ferro-silicon as follows :

Period	*Annual ingot steel output*	*Ferro-silicon needed annually*	*Ferro-manganese needed annually*
End of Third Five Year Plan	10 million tonnes	25,000 tonnes	125,000 tonnes
End of Fourth Five Year Plan	18 million tonnes	45,000 tonnes	225,000 tonnes

(a) Fe-Si grade would contain 75% Si.

(b) Approximately 25 lbs of Ferro-manganese needed per tonne of steel

(c) Approximately 5 lbs of Ferro-silicon needed per tonne of steel.

Likewise, the estimated demands of ferro-alloys for non-alloy iron and steel foundry requirements are given below :—

DEMANDS FOR NON-ALLOY IRON AND STEEL (PLAIN CARBON) FOUNDRY REQUIREMENTS

Ferro-manganese and Ferro-silicon	
At the end of the Third Five Year Plan	Non-alloy Iron Castings including malleable grade—2 m. tonnes/yr and plain carbon steel castings 110,000 tonnes per year
Ferro-manganese	2,500 tonnes per year
Ferro-silicon	1,500 tonnes per year
At the end of the Fourth Five Year Plan	Iron Castings including malleable grade 4 m. tonnes/yr and steel castings 300,000 tonnes/yr.
Ferro-manganese	5,200 tonnes per year
Ferro-silicon	3,500 tonnes per year

Requiremens of ferro-chrome for non-alloy iron and plain carbon steel foundry requirements :

At the end of the Third Five Year Plan	950 tonnes/year
At the end of the Fourth Five Year Plan	2000 tonnes/year

The figures, on the previous page, will include some quantities of ferro-alloys needed for indigenous production of exo-thermic compounds used in iron and steel foundries.

Consumption of other ferro-alloys for non-alloy iron and plain carbon steel foundries, such as of ferro-molybdenum, ferro-titanium etc. would be at best marginal in character and is omitted from these estimates. For ferro-phosphorus, however, some provision could be made for the above applications viz., 300 tonnes and 550 tonnes by the end of the Third and Fourth Five Year Plans respectively.

The importance of the establishment of ferro-alloy industry to feed the alloy, tool, special and stainless steel industry hardly needs to be emphasized when it is realised that to meet the annual requirements of 0.5 million tonnes a year of alloy, tool, special and stainless steels, the corresponding ferro-alloys requirements would be of the order of 120,000 to 125,000 tonnes per year, including special types of ferro-manganese but excluding all general purposes ferro-manganese and ferro-silicon needed for the production of plain carbon, mild and structural steels.

It would, therefore, be appreciated that unless a ferro-alloy industry is now established, the requisite ferro-alloys will have to be imported entailing tremendous foreign exchange expenditure, the estimated amount could well exceed Rs. 700 million a year to import the ferro-alloys' requirements for a 0.5 million tonnes a year output of alloy steels to be provided for by the end of the Third and at the start of the Fourth Five Year Plans. It is felt that a ferro-alloy plant capable of producing 25,000 tonnes of different grades of ferro-alloys per year should be immediately set up and it should be increased in stepped up phases upto a capacity of 110,000 to 125,000 tonnes per year when the alloy steels' annual production would be expected to be of the order of 500,000 tonnes.

Excepting nickel, molybdenum and cobalt, resources of which hardly exist in India, all other ferro-alloys can be produced from indigenous resources on an industrial scale, provided requisite technical 'know-how' suited to indigenous raw materials is readily developed—in this task of formulating indigenous technical 'know-how' consistent with acceptable economics of production and requirements of quality output, the National Metallurgical Laboratory is now actively engaged both on laboratory as also pilot plant scale research investigations. With this basic objective of developing indigenous 'know-how' for the production of diverse ranges of ferro-alloys and for formulating electric smelting techniques for the indigenous ores, a pilot electric sub-merged arc ferro-alloy furnace was commissioned at the National Metallurgical Laboratory with a capacity of 1-2 tonnes of different types of ferro-alloys output per day.

The author had given some estimates of ferro-alloy requirements for alloy, tool, special and stainless steel industry at the International Symposium[1] organised by the

1. Proceedings of the International Symposium on "Ferro-alloy industry in India" organised by the National Metallurgical Laboratory, published in 1962.

National Metallurgical Laboratory in February 1962, excluding the requirements for plain carbon, mild and structural tonnage steels as given in Table 6.

Table 6

	Alloy, tool, special and stainless steels capacity 200,000 tonnes per year	Alloy, tool, special and stainless steels capacity 375,000 tonnes a year
Ferro-alloys	*Requirements in tonnes/year (approx.)*	
Ferro-chrome (65% Cr)	26,000	50,000
Ferro-silicon (50% Si)	7,000	15,000
Ferro-manganese (special grades) (75% Mn)	3,000	6,000
Electrolytic manganese (99% Mn)	3,500	6,000
Ferro-tungsten (70% W)	2,500	5,000
Ferro-molybdenum (70% Mo)	450	950
Ferro-vanadium (50% V)	300	650
Others	500	1,000
Total	43,250	84,600

Requirements of carbon-free ferro-alloys and alloying elements are given in Table 7. These estimates have been included in the above Table No. 6 for an annual output of 375,000 tonnes of alloy, tool, special and stainless steels per year.

Table 7

1.	Carbon free ferro-chrome	1,000	tonnes
2.	Ferro-vanadium	650	,,
3.	Ferro-titanium	200	,,
4.	Ferro-tungsten	5,000	,,
5.	Ferro-boron	50	,,
6.	Ferro-zirconium	less than 50	,,
7.	Chromium metal (95%)	100	,,
8.	Manganese metal (95%)	100	,,
9.	Ferro-chrome-manganese	Regular demand of nitrogen bearing ferro-chrome and nitrided manganese alloy will be established after the production of nickel-free austenitic stainless steel has been initiated in the country on the basis of researches undertaken at the National Metallurgical Laboratory.	
10.	Ferro-molybdenum	950	tonnes

It would thus be seen that a clear scope exists for the production of carbon-free special ferro-alloys by alumino-thermic reaction, to meet the requirements of the alloy steel industry. The demand will gradually increase to 10,000 tonnes a year or more when the annual production of alloy and special steels rises to 0.5 million tonnes.

The estimated requirements of different types of ferro-alloys including carbon free ferro-alloys as stated above are given in Table 8 for respective estimated output of alloy, tool, special and stainless steels excluding the plain carbon mild and structural steels.

Apart from the supply of raw materials of the right type and in adequate quantities, the most important factor for a ferro-alloy industry is cheap and abundant electric power as the reduction takes place by the electro-metallurgical process. The advantages of cheap electric power would over-ride other considerations such as market and transport. Freight charge is only a small fraction in the 'all-in' cost of the product, at the consumer's end. Some raw materials such as manganese ore and silica (quartzite) and titanium ores occurred in abundance to meet the full requirements, of the steel industry. Some materials like chromium and vanadium ores are available only in limited quantities and, others like tungsten ores, molybdenum ores, cobalt, nickel, etc. have to be imported, as no economic resources exist in the country. Ferro-chromium is the most important ferro-alloy which is required

Table 8

Ferro-alloys	Alloy, tool, special & stainless steels capacity 500,000 tonnes per year equivalent to present licensed capacity.	Alloy, tool, special & stainless steels capacity 1 m. tonnes per year at the end of the 3rd & start of the 4th Five Year Plans	Alloy, tool, special & stainless steels capacity 1.8—2 million tonnes per year at the end of the 4th Five Year Plan
	(Tonnes)	(Tonnes)	(Tonnes)
Ferro-chrome (65% Cr)	70,000	14,000	260,000
Ferro-silicon (50% Si)	25,000	50,000	95,000
Ferro-manganese (special grade) (75% Mn)	10,000	20,000	35,000
Electrolytic manganese (99% Mn)	8,000	16,000	30,000
Ferro-tungsten (70% W)	7,000	14,000	27,000
Ferro-molybdenum (70% Mo)	1,500	3,000	5,000
Ferro-vanadium (50% V)	1,000	2,000	3,000
Others	2,500	5,000	10,000
	125,000	250,000	465,000

in large quantities and for which adequate capacity has to be established. It is underrstood that although some firms have been licensed to manufacture ferro-chrome, so far no plant has come into production. In the recent technique of production of ferro-alloys, particularly ferro-chrome and ferro-silicon, the multiple hearth operation has made it possible to reduce the capital investment.

A summary of the raw materials required and their locations are given below :—

Raw material	*Estimated reserves and grade*	*Location*
1. Manganese ore	180 million tonnes (60 million tonnes suitable for manufacture of ferro-manganese).	Madhya Pradesh, Maharashtra, Orissa, Mysore, Andhra Pradesh, Rajasthan, Bihar and Bengal.
2. Titanium (as ilmenite in beach sands)	300 million tonnes (Extensive deposits)	Kerala, Madras, Maharashtra, Andhra.
3. Titaniferrous magnetite	70 million tonnes (Extensive deposits) TiO_2 4 to 25%	Bihar, Orissa, Mysore.
4. Quartzite (Silica)	Extensive deposits	Mysore, Bihar, Orissa.
5. Chromite	3 million tonnes (limited quantities of metallurgical grade) 48% Cr. Cr/Fe 2.5 to 4	Orissa, Mysore.
6. Vanadiferrous magnetites	20 million tonnes (High ores very limited) V_2O_5 2.2 to 3%	Bihar, Orissa, Mysore.
7. Tungsten	No estimate (very small reserves)	Rajasthan, West Bengal.
8. Cobalt	No workable deposit	Ultrabasics of Manipur with copper in Rajasthan, with Wad in Orissa.
9. Nickel	No workable deposit	—
10. Molybdenum	No workable deposit	Sporadic occurrences in Bihar, Madras and Kerala.
11. Zircon	Adequate reserves	Beach sands of Kerala.
12. Fluorite	3 million tonnes (limited)—Flux Gujarat : 1 million tonnes —more than half with 50% CaF_2 and Rajasthan : 2 million tonnes with 4 to 25% CaF_2	Gujarat and Rajasthan.

One of the important factors required for the success of a ferro-alloy industry is cheap electric power. As almost all ferro-alloys are produced in electric furnace, the electric power consumption is very heavy. Electric power rates in India differ from State to State and the rates charged per unit vary from 0.02 nP. to 0.6nP, and even more.

The electric power required for the production of various ferro-alloys is given below :

Ferro-alloy	*Power in KWH/ton*
High carbon ferro-manganese 75% Fe-Mn	3,600 - 4,000
High Carbon Fe-Cr	5,000
Medium Carbon Fe-Cr	8,000 - 9,000
Low Carbon Fe-Cr	10,000 -12,000
Silico-Manganese (75% Mn, 20% Si)	6,000
Fe-Si (45% Si)	5,500 - 6,000
Fe-Si (75% Si)	8,500 -10,000
Fe-Si (90% Si)	14,000 -15,000
Smelting, ilmenite-titanium slag and pig iron	3,500 - 4,000
Fe-Mo (70% Mo, 1% C)	7,000
Fe-W (80% W, 1% C)	8,000

A brief note elucidating the raw materials and uses of the different ferro-alloys is given below :-

Ferro-Manganese

There are ample reserves of manganese ore in the country and the licensed capacity is 200,000 tonnes of ferro-manganese a year. All this tonnage will be high carbon (6% to 8% C) ferro-manganese, made in electric furnace. The demand for low carbon ferro-manganese has been very small uptil now. There should be no difficulty in establishing sufficient capacity for the manufacture of low carbon ferro-manganese and also silico-manganese, when there is sufficient demand.

In the manufacture of certain types of stainless steels and alloy steels, electrolytic manganese is employed. As there is abundant raw material, there will be no difficulty in the manufacture of electrolytic manganese. Cheap electric power should however be available.

Ferro-Silicon

Ferro-silicon is manufactured by the Mysore Iron & Steel Works, Bhadravati, and they have a capacity of 20,000 tonnes a year. Suitable raw materials are available in sufficient quantities and there will be no difficulty for the manufacture of ferro-silicon, both of the 50% and 75% grades.

Ferro-Chromium

Chromite (Cr_2O_3) deposits occur in Orissa, Bihar, Andhra Pradesh and Mysore. The Orissa deposits are known to be of the metallurgical grade, while that of the other States which have a lower chromium content and a higher chrome/iron ratio, are suitable for the manufacture of refractories. Most of the current high grade chromite production comes from Orissa. Metallurgical grade ore suitable for making ferro-chrome should contain a minimum of 48% Cr_2O_3 and chrome-iron ratio of 3.0% or better.

The total reserves of chrome ore are estimated to be approximately 3.0 million tonnes. An intensive search should be made to prove the total reserves of chromite as also the quality of the ore. Approximately 3.4 tonnes of chrome ore of 48% grade will be needed for the manufacture of 1 tonne of ferro-chrome (68% Cr). Approximately 170,000 tonnes of ore will be required for the production of 50,000 tonnes of ferro-chrome.

High carbon ferro-chrome is manufactured in open sub-merged arc electric furnaces. The high carbon ferro-chrome is further refined to produce the low carbon grades. While the manufacture of high carbon grade is a straight-forward and simple matter, the production of low carbon grades presents many technical difficulties. The refinement is carried out in a two step process or by the ferro-chromium-silicon reduction. Russia has developed a vacuum decarbonisation method, which is of great promise. The alumino-thermic process has been found to have limited use on account the high cost but it is useful when small quantities are to be made without recourse to large capital expenditure.

Ferro-Tungsten

Tungsten is the principal alloying element used for high speed steels. Tungsten ore (Wolframite) occurs in very limited quantities in Rajasthan, and Bankura in West Bengal. For the manufacture of ferro-tungsten as well as tungsten-carbide, it would be necessary to import tungsten concentrates from Burma or other countries.

Ferro-Molybdenum

Ferro-molybdenum is used in a large variety of alloy steels. The ore of molybdenum is Molybdenide (a sulphide of the metal). Although molybdenum has been found in various places in India as an associate mineral of lead, copper and zinc, no workable deposits have been proved. India will have to depend on outside sources of supply.

Ferro-Vanadium

There are large deposits of titani-ferrous magnetite iron ores in the Singhbhum district containing 0.55 to 5% $V_2 0_5$. The reserves of these deposits have been estimated to be about 20 million tonnes. From the experiments conducted, it is ascertained that about 60% of the vanadium content can be recovered. The recovery follows a chemical process, of roasting the mixture of crushed ore and soda-ash and leaching the vanadium salt with ammonia for further treatment with sulphuric acid. This is an expensive process.

Another possible source of $V_2 0_5$, is as a by-product of alumina industry. The bauxite used in aluminium manufacture contains small percentage of $V_2 0_5$ which can be recovered as a by-product. As enormous quantities of bauxite are treated for the manufacture of aluminium, it is expected that sufficient tonnage of $V_2 0_5$ would be available. However, the economics of the process and the quantity that can be recovered have yet to be worked out.

Ferro-Titanium

Ferro-titanium is used as a stabiliser in stainless steel and as abundant raw materials for the manufacture of ferro-titanium are available, there will be no difficulty in manufacturing all the ferro-titanium required. It may be pointed out that the recent developments indicate that ferro-titanium is going out of use as a stabiliser in stainless steels.

Other Ferro-Alloys

Small quantities of specialised ferro-alloys such as ferro-boron, ferro-zirconium, ferro-neobium, misch-metal, etc. will be required for certain grades of special steels. These can be either manufactured locally or can be imported as the foreign exchange involved will not be large.

Nickel and Cobalt

No workable deposits of nickel and cobalt have been located so far, although a few minor occurrences have been reported. India will have to depend on the import of these two metals. It may be pointed out that there is only one country in the world viz. Canada, that supplies over 85% of the world's requirements of nickel.

Indian Raw Materials for Iron and Steel Industry

The problems of an iron and steel industry inevitably and continually revolve around its basic raw materials, production techniques, operational skill, efficient plant maintenance etc. The basic raw materials for an iron and steel industry are iron ore, fuel, the fluxes, iron and steel scrap etc. In this review, references will be only made to Indian iron ores and steel-making quality limestone flux since the position of Indian coal and coke is now well-known over the last decade or two. For Indian iron ores and steel-making quality flux, the metallurgical story has unfolded only during the last few years, indicating specifically their deficiencies and remedial measures absolutely essential ; the impact of such revelations has been rather sudden but it goes to the credit of all concerned that the acceptance of remedial measures formulated on the basis of painstaking laboratory and pilot plant scale researches undertaken at the National Metallurgical Laboratory, has been equally quick. Details of these metallurgical research investigations and their economic implications were discussed at the last International Symposium on Iron and Steel-making with special reference to Indian conditions, held at the National Metallurgical Laboratory in February 1963[2].

Iron Ores

Despite somewhat opposing views, it has now been acknowledged in responsible quarters that Indian iron ores to be classified as one of the classic rich iron ores of the world may not be wholly plausible in a strictly metallurgical sense. The metallurgical characteristics of a classic rich iron ore will basically depend on the nature and characteristics of the ingredients constituting its gangue and the latter's physical mode of distribution and structural association with metallic values of the ore and the gangue's selective presence in different ore size fractions. The gangue content of some of the Indian iron ores resides in the finer ore fractions, such as in—1/2" which under the heavily mechanised iron ore mining conditions now introduced in India can constitute between 1/3rd to 1/2 of the total iron ore thus mechanically extracted. The full impact of the problem, with which India is faced, relating to the release, storage and utilisation of the masses of iron ore fines to be mined during our successive Five Year Plans will multiply to a magnitude that it

2. Publication issued by the Iron and Steel Institute (UK) containing the pre-prints of all papers presented at the International Symposium jointly organised by the National Metallurgical Laboratory and the Indian Institute of Metals in collaboration with the Iron and Steel Institute, London.

will defy scientific solution unless adequate attention is focussed on this important subject and effective steps are introduced to utilise such iron ore fines. Table No. 9 gives some data on the projected developments in iron ore requirements for home use and export.

The above classification is based on expected output of 40-41 million tonnes a year of iron ore for domestic consumption and 25 million tonnes a year for export by 1970-71. It is, therefore, stressed that utilisation of iron ore fines has to be rationally and comprehensively examined for exploitation of what would one day perhaps constitute the biggest national waste of assets and which no other country is likely to permit in view of the practical availability to-day of advanced technology for their utilisation.

Indian iron ore fines

Utilisation of iron ore fines in India is complicated by the Indian weather conditions. The subject was quite simple when hand-mining was resorted to and selective mining yielded lump size iron ore materials from which the fines were discarded in situ. However, with the introduction of heavy mechanised mining, separation of the ore fines by manual methods from the lumps cannot be attempted or successfully accomplished. It is thus obvious that all the iron ore fines would thereby be sent to the ore handling and screening plant along with the lumpy material which can cause severe complications under Indian weather conditions of heavy tropical rain. It has been the experience in India of the Steel Plants that under Indian tropical weather conditions, the screening and the handling systems become completely blinded and choked due to muddy conditions caused by the action of tropical rain on the admixture of iron ore fines with the lumpy material. It is in this context that the entire subject would have perhaps assumedsome what less significance and importance, had it not caused serious difficulties and plant dislocations in ore handling and movement caused by blinding of the screens during heavy monsoon rainy weather.

In the absence of suitable ore handling, screening and beneficiation methods to prevent the blinding of the screens, such as through wet screening and scrubbing the iron ore followed by dewatering classifier treatment (the slime containing at times upto 25—40% insolubles), a modern ore handling and screening plant involving capital outlay of several crores of rupees can be ultimately, even though majestically, brought to a standstill. As such, the establishment and operation of a sinter production plant which naturally consumes these iron ore fines, is seriously hindered, if not altogether blocked. It is thus of paramount importance that all avenues should be explored (i) to separate the fines from the lumpy iron ore materials both in fair and rainy weather and (ii) to utilise the iron ore fines thus separated to the maximum national advantage for home smelting. Comprehensive investigations have been undertaken at the National Metallurgical Laboratory on pilot plant beneficiation investigations on Bolani iron ores for Durgapur Steel Plant, Barsua iron ores for Rourkela, Kiriburu iron ores for the National Mineral Development Corporation, iron ores for the Tata Iron and Steel Works and Rajhara iron ores for Bhilai Steel Plant etc.

Table 9

Projected Developments in Iron Ore Requirements for Home use and Export

(All figures in million tonnes per year)

Year	*Steel capacity installed*	*Iron ore requirements for home use*	*Home consumption Approximate installed capacity at large mines*						*For export Kiriburu and Bastar/Raipur, Bailadilla, Goa, etc.*
			Rourkela — Barsua	Durgapur — Bolani	Bhilai — Rajhara	Tisco — Various captive mines	IISCO — Goa	Bokaro — Largely Kiriburu and new mines Taldih, Meghathaburu and Sasangdah	
1960-61	6.00	9 to 10	2.00	1.00	2.00	3.10	2.00		3.40
1965-66	10.00	19.00 to 20.00	3.50	3.00	4.50	3.50	2.00	Upto 3.00 (from Kiriburu about 1.5 million tonnes fines)	12
1970-71	20.00	40.00 to 41.00	(Currently under detailed study for formulating expansion Plans)						25.00

Further investigations will cover iron ores from Bailadilla, Taldih, Sasungdah and other captive mines of Hindustan Steel Limited and of private sector Steel Plants in the country.

Perhaps the most important method of utilisation of iron ore fines is the use of sinter including self-fluxing sinter. The use of sinter in iron smelting both of self-fluxing or non-fluxing is no longer a field merely of academic interest presenting any unusual features that are to-day unknown. All the world over, iron production plants are operating with as much as in most cases 100% sinter charge with considerable increase in iron productivity based on low fuel rates. These sintering techniques utilise almost the entire iron ore fines released during mechanised mining and offer acceptable solution in two ways : one being the effective utilisation of the iron ore fines which otherwise will present serious disposal and storage problems and the other, effectively increasing the metal iron output by extracting the metallic values of the ore fines, involving reduced fuel rates through the medium of the sinter. It stands to reason that of 100 units of mechanised mined iron ore, if 40 units of iron ore fines are to be discarded, the cost of mining operation will be high. It is therefore necessary from considerations based on cost of mining alone to utilise these 40 units of iron ore fines by all possible techniques acceptable under Indian conditions of weather and operational facilities.

Even where ores of good quality are available, such as in the U.S.S.R., sinter production is resorted to ensure ores of uniform quality and yield a self-fluxing burden to the blast furnace. In the case of lumpy iron ores being fed into the blast furnaces in India during rainy season, considerable amounts of iron ore fines tenaciously adhere to the ore lumps. If these iron ore fines are removed from the lumpy material by simple treatment, such as washing, scrubbing and wet screening, the lumpy iron ore materials would present to the blast furnace maximum burden permeability yielding increased productivity.

Research investigations undertaken by the National Metallurgical Laboratory during the last few years have undoubtedly aroused the interest of Indian iron and steel industry in not only fully appreciating the desirability but also the scientific necessity of adopting optimum beneficiation techniques in the context of Indian weather conditions coupled with characteristic nature and quality of Indian iron ores being exploited. It has been shown that a sinter plant operating with unbeneficiated iron ore fines will not yield the performance expected of it. This is distinctly apart from the position that even should it be possible to handle and screen natural iron ore fines in Indian rainy weather, the sinter produced from natural untreated iron ore fines will be metallurgically of little value in terms of increased iron productivity, lowered coke and flux rates apart from ensuring smooth and hanging-free furnace operations. It is not merely necessary to produce sinter at any cost and of any grade but in order to obtain from its use full iron output potential, it should be of a good metallurgical grade with distinct well established benefits arising through its application. It should also be borne in mind that it is necessary to incorporate return sinter fines in the sinter mix, which following also requisite additions of high-ash coke breeze will make the acid contents (alumina and silica combined) abnormally high in cyclic sinter feeds. Such successive incorporation of return sinter fines in the sinter mix made up of unbeneficiated ore fines, will continuously build up the acid contents of the sinter feed to an alarming extent which in cyclic operations will render the resulting self-fluxing sinter of poor physical strength and metallurgical value to be acceptable. These undesirable factors exercise cumulative deteriorating effects when the sinter plant goes into continuous production yielding weak, friable and poorly reducible sinters made out of unbeneficiated iron ore fines.

Limestone (Steel-making quality)

Limestone is the most important flux used in iron and steel-making. When the steel output in India was small, lime-stone with less than 5% insolubles could be obtained. With the heavy demands of the expanding iron and steel industry both in the public and private sectors on limestone, the quality of the latter has deteriorated rapidly with insolubles therein rising to 12-13%, causing thereby heavy deficiencies in the fluxing power of the limestones for steel-making, turning it into "slag making" both literally as also metaphorically. Realising the importance of the subject, the National Metallurgical Laboratory has during the last few years undertaken series of investigations for optimum economic beneficiation and agglomeration of limestone for steel-making. For limestone to be used as metallurgical flux in steel-making, maximum availability of base CaO is necessary and for that purpose, silica content of the limestone should be low so that its CaO base is not used up in fluxing its own silica at the expense of the acids arising out of the oxidation of metalloids in a steel-making bath, such as silica and P_2O_5 which have, of necessity to be fluxed into the slag. Limestone for use in steel-making should contain very low silica contents preferably of the order of 1—2%, even though the open-hearth grade Indian limestone is specified to contain not more than 6% acid insolubles, corresponding to about 7.5% total insolubles. The quality of the Indian limestones used in steel-making vis-a-vis their silica content is deteriorating and the insolubles in limestone for steel-making are now of the order of 12—15%. With these poor grades of limestone, production in the Steel Plants can be adversely affected apart from the operational difficulties arising, such as of poor heat-exchange between the furnace gases and the steel bath, causing damage to the furnace roof thereby, high consumption of the limestone itself in order to meet the flux needs of the acids resulting from the oxidation of metalloids, danger of reversion of phosphorus from slag to metal during steel-refining due to lack of stabilizing base in the slag and dangers of off-heats etc. The limy slag cover itself is a good heat insulation over the molten metal bath and with increase in its thickness, the inadequacy of effecting maximum heat-exchange so necessary in open-hearth steel-making, will become apparent causing loss of the steel output and higher production costs, heavy maintenance expenses etc. The cumulative effects of these factors can be far more adverse than is fully realised. Limestone used for calcination to yield burnt lime is specified to contain a total of 10% acid insolubles corresponding to 12% total insolubles. The burnt lime is also used in the open-hearth steel-making to meet inevitable deficiencies of the base CaO during refining stages of open-hearth steel-making. If, however, through suitable limestone beneficiation, silica contents of the limestone can be reduced to about 2%, adequate CaO base would thus be available and as such, addition of burnt lime during steel-refining may not be necessary, which would naturally mean savings in the flux costs considering that the burnt lime costs approximately three times that of limestone.

The severity of the problem will be realised when the steel production in India, projected at 20 million tonnes of steel per year at the end of the Fourth Five Year Plan has to be physically attained—the contrast will become sharper with increasing deterioration in the quality of metallurgical grades of limestone and lack of its adequate indigenous resources. It would therefore be appreciated that benefication of limestone for steel-making will become a crucial metallurgical necessity, if not an absolute economic necessity. It has been argued that any industrial application of beneficiation techniques must be based on economic advantages thereby accruing. As such, the beneficiation costs have to be adjudged in the ultimate analysis against the lowered consumption of the limestone flux, acceleration in steel-making following on increased reactivity of the up-graded limestone concentrate, reduced possibilities of off-grade steel heats and less damage to the furnace roof etc. It will be difficult to straightaway evaluate the improved economics resulting from the use of beneficiated limestone at this stage even though there are clear indications thereto. It has been shown in these investigations that the up-graded limestones can be adequately pelletized without expensive binders and the pellets possess adequate strength for handling and providing necessary lime boil in open-hearth steel-making. An extremely well-equipped and fully integrated Mineral Beneficiation Pilot Plant is currently in full operation at the National Metallurgical Laboratory, with a capacity of treating upto 5 tons of a particular ore per hour depending upon its nature and that of the concentrate needed, involving a capital outlay of Rs. 50 lakhs (about a million dollars) during the Third Five Year Plan.

The use of beneficiated limestone in iron-making in the blast furnace has not been taken up, even though increasingly high ash contents of Indian coke will require in turn additional quantities of the limestone flux. The limestone briquettes required for blast-furnace have to be exceedingly strong unless the upgraded limestone which is in the form of fines is directly used for making self-fluxing sinter. The reduction in silica content of the beneficiated limestone for use in iron production will have to be balanced against the high alumina contents of Indian blast-furnace slags requiring certain minimum silica values therein. [3,4]

3. Dr. M. N. Dastur, Steel and Long-term Planning: An Address to the Administrative Staff College, Hyderabad, on Feb. 28, 1963.

4. Dr. M. N. Dastur, Steel in India—Economic and Technological Possibilities, The 4th Sir M. Visvesvaraya Lecture delivered at the 41st Annual Convention, Bombay, on February 4, 1961.

Small Foundry Iron Production Plants

The importance of small Plants for iron production has been focussed by the National Metallurgical Laboratory through extensive Pilot Plant trials at its Low Shaft Furnace Pilot Plant; relevant technical results and recommendations were presented at the last International Symposium on "Iron and Steel-making with particular reference to Indian conditions" held at the National Metallurgical Laboratory[5,6,7]. The subject has also recently been aptly discussed and well presented by Dastur[3,4] and by Dowding and Whiting[8]. Sir Jehangir Ghandy in one of his Addresses[9] has also aptly presented the scope of small iron-making and steel plants particularly under Indian conditions.

Several industrial licences have been granted for small foundry iron-making plants in the country based on regional utilization of raw-materials.

In most steel producing countries to-day, the flourishing of both big and small plants dispersed on the basis of raw-materials' regional distribution and transport facilities is often met with. Even in the United States, there are several small plants with an annual capacity of a few hundred thousand tonnes whilst integrated iron and steel complexes of over 6 million tonnes annual capacity do not exceed half a dozen. Likewise in Japan, new small foundry iron plants are currently being established, whilst there are a number of small plants successfully operating besides integrated iron and steel complexes embodying as if it were the principle of "walking on both the legs". The small plants specifically cater to the regional requirements of premium quality iron production. The explanation that the small plants may be carried over from earlier days, is only partly valid since new small plants are also being concurrently established. The parallel growth of integrated iron and steel complexes and small foundry iron plants is a step in the right direction both in advanced and under-developed countries. The total indigenous fabrication of such small plants in India to-day is a full-scale possibility and would encourage the growth in turn of related engineering industries. The growth

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5. Dr. A. B. Chatterjea and Dr B. R. Nijhawan. Iron production in low-shaft furnace plants with Indian raw-materials. National Metallurgical Laboratory Symposium Volume on 'Recent developments in iron-and steel-making with special reference to Indian conditions', Feb. 1963.

6. Mr. P. H. Kutar and Dr. B. R. Nijhawan, Some problems of iron-and steel-making in the Hindustan Steel Plants. Publication issued by the Iron and Steel Institute (UK) containing the pre-prints presented at the International Symposium organised by the National Metallurgical Laboratory and the Indian Institute of Metals in collaboration with the Iron and Steel Institute, London.

7. Messrs. P. I. A. Narayanan, G. V. Subramanya and G. P. Mathur, Beneficiation, sintering, and processing of raw materials for the iron and steel industry, publication issued by the Iron and Steel Institute (UK) containing the pre-prints presented at the International Symposium organised by the NML and the Indian Inst. of Metals in collaboration with the Iron & Steel Institute, London.

8. Messrs. M. F. Dowding and A. N. Whiting, The case for 100,000 tonnes/yr integrated iron and steel plants for emergent countries, publication issued by the Iron & Steel Inst. (UK) containing the pre-prints presented at the Symp. organised by the NML, IIM in collaboration with Iron & Steel Inst. (UK).

9. Sir Jehangir Ghandy, Outlook on Steel, Address to the Defence Staff College at Wellingdon, on Feb. 22, 1963.

of the small iron-making plants can be based on the use of surplus nut coke from integrated steel plants, or alternative fuels, such as the low temperature carbonized coke or lignite coke made from Neyveli lignite in South India. The industrial scale production of low temperature coke (Kolsit) from Singareni non-coking coals has been well established by Regional Research Laboratary (Hyderabad) of the Council of Scientific and Industrial Research. In extended full- scale trials on iron smelting in the Low-Shaft Furnace Pilot Plant of the National Metallurgical Laboratory, Kolsit proved an ideal fuel for iron production—equally favourable results were achieved with low temperature coke made from non-coking coals from the Bengal-Bihar basin. The low temperature coke is more reactive than hard metallurgical nut coke which itself is an alternative sub-standard fuel for iron smelting. Foundry iron production through electric smelting is also feasible in India, as currently projected in Rajasthan and South India where optimum electric power rates are available. The above possibilities form the basis for the grant of industrial licences for foundry iron production in the Punjab, Andhra Pradesh, Rajasthan, Maharashtra (Western India), Goa and Orissa etc. whilst similar installations are being actively considered in Gujarat. Likewise, small foundry iron blast furnaces attached to the integrated Hindustan Steel Plants as "satellite" installations are also being currently considered. A small foundry blast furnace with the minimum of mechanisation of 100 tonnes daily output, with 2/3rd of its cleansed gas bleeding and sand bed casting has been most successfully and economically operating in India at Barbil (Orissa) for the last several years, originally established with a capital outlay includng housing and land, of about Rs. 250 per annual tonne of iron. It would indeed be hard to put up a big blast furnace to-day for foundry iron production on identical capital outlay per annual tonne of iron.

A modern high output giant blast furnace with all its latest ingenious and expensive auxiliaries, is intrinsically an highly capital intensive unit; more so, if its capacity is utilized merely to produce a relatively low cost, intermediate and crude product viz., foundry pig iron. Thus to utilise the giant blast furnace with its high initial capital investment and over-heads of heavy, integrated iron and steel complex for foundry iron-making may in most cases not be altogether acceptable on economic grounds; in the ultimate analysis however, it would tantamount to producing a crude semi-finished product in a heavily capitalised integrated iron and steel complex, instead of giving the same crude semi-finished product its logical steel product-mix, which would thereby effectively ensure maximum capital returns and dividends on the heavy capital investment made. Thus, any foundry iron made in a heavy iron and steel complex would in most cases be at the expense of corresponding if not greater output of steel and its finished high premium product-mix, yielding thereby unfavourable capital returns. It is hardly necessary to indicate that integrated iron and steel bases are normally well balanced complexes. At the same time it is well-known to-day that blooming rolling-mill capacity is normally kept well in surplus in relation to iron and steel-making potential in a modern, integrated iron and steel plant; this flexibility would enable the operation of the blast furnace plant exclusively on basic iron for steel-making. In this country, integrated steel plants have hitherto supplied the major foundry pig iron requirements of engineering industries. Prior to last World War II, however, the spread over of the demands of steel end-products did not follow any uniformly planned or steady patterns thereby making room for switching over of iron-making capacity from basic to foundry grades of pig iron. The situation to-day has undergone radical changes, amply justifying the stand that the responsibility for foundry iron-making should progressively and exclusively pass on to non-integrated blast furnaces.

World-wide trends, in general, favour the production of foundry iron in relatively smaller blast furnaces. In India, the reserves of metallurgical grade coking coals are extremely poor, estimated at about 1500 million tonnes[10]. The operations of big blast furnaces are dependent upon the use of optimum sized good grade metallurgical coke, home made or imported. It is thus emphasized that big blast furnaces should be used for making only basic iron to be refined into steel and finally processed into specific product-mix, whilst the smelting of foundry iron ought to be undertaken in comparatively smaller blast furnaces which can operate on alternative Indian fuels referred to earlier. Such measures would be metallurgically feasible and economically acceptable and from the standpoint of highly scanty proved reserves of indigenous metallurgical fuels, perhaps offer the only solution both on short-term and long-range basis. The opportunity thus exists of bridging the present gap between the demand and supply of foundry grades of pig iron and of ensuring additional supplies for the future, independently of integrated iron and steel bases currently in operation or those planned.

India is a land of long distances involving heavy rail freight costs which can more than off-set any increase in the iron production cost in small regionally dispersed foundry iron-making units; the latter can well pattern the in-tandem growth of medium and light engineering industries region-wise, over a thousand miles away to the north and south of the major Indian integrated steel plants located to-day in the Bengal-Bihar-Madhya Pradesh belt. This then depicts the general Indian pattern of foundry iron-making in small plants in the broad spectrum covering the growth of iron and steel industry in India since the last World War. The subject has been critically discussed at different platforms in India and abroad by various authors, including the last International Symposium on "Iron and Steel-making with particular reference to Indian conditions" held at the National Metallurgical Laboratory in February 1963 and earlier in February 1959 on "Iron and Steel Industry in India". Figure 3 shows the Low-Shaft Furnace Pilot Plant of the National Metallurgical Laboratory which has produced several thousand tons of foundry grades of

10 Dr. B. R. Nijhawan, Iron & Steel Industry in India, Symposium Volume on 'Iron & Steel Industry in India', p. 332-337, symposium held at the National Metallurgical Laboratory in 1959 (Feb).

pig iron from regional raw-materials from different parts of India since it went into operation in February 1959. The results obtained on the metallurgical feasibility and economic acceptability of iron smelting with regional raw-materials in the Low-Shaft Furnace Pilot Plant have been very valuable in determining the growth pattern of foundry iron production in small plants.

Conclusions

Fast developing countries, such as India have fully realized the importance of well-knit and integrated iron and steel bases to feed the chain-reaction growth of secondary and processing engineering industries that in turn form the backbone of consumer industries catering to the multitude needs of diverse products essential both in times of war and peace. Whilst, the iron and steel industry is highly capital intensive, no country can afford to leave it to the vagaries of international trade. The rise of such an industrial developing economy in under-developed countries, would however provide the basis subsequently of growth on "ones own legs" and not an alien superstructure based on the imports of iron and steel that is unlikely to withstand the stresses of peace and least of all the strains of war. The establishment of home iron and steel industry provides in the ultimate analysis a self sustaining economy to assist a fast developing country, such as India, to the stage of an economic "take-off".

Such growth pattern of iron and steel industry in India in her economic development through Five Year Plans has not been without its inevitable tale of sweat and toil through which India is passing in its steady yet sure march in not only attaining self-sufficiency in iron and steel but also in her ultimate objective of becoming a leading iron and steel producing country in the world.

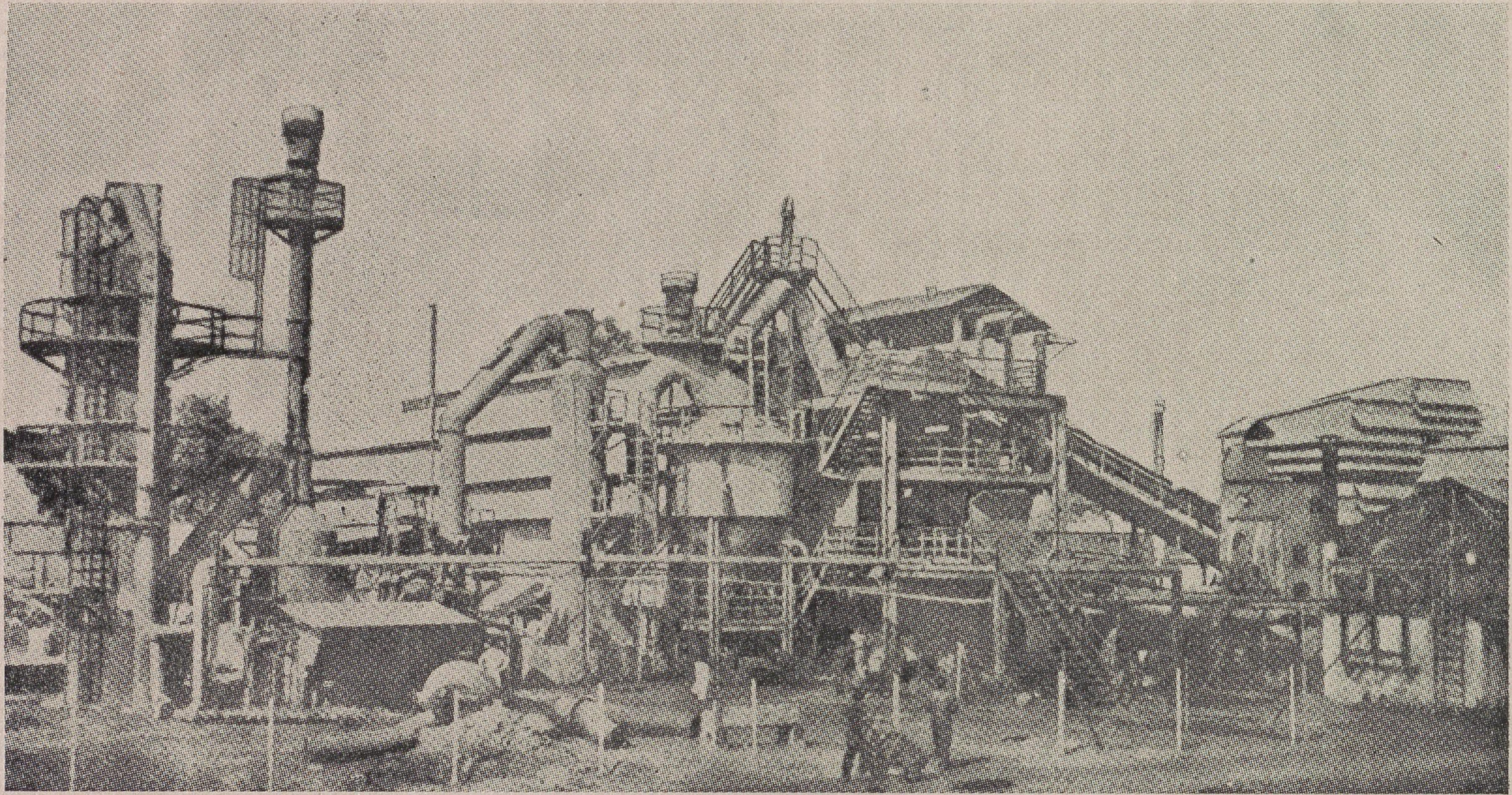

Fig. 3 The Low-Shaft Furnace Pilot Plant of the National Metallurgical Laboratory

Role of Science and Technology in Indian Agriculture

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Man evolved from anthropoid apes about a million years ago. About 5 lakh years ago he became a hunter and a food-gatherer, and made rough tools out of stones for cutting the carcases of animals and for flaying skins. About 4 lakhs of years ago he discovered the use of fire and made wooden spears tipped with flint heads. About a lakh of years ago he domesticated animals allied to foxes and wolves into dogs who became his companions in hunting wild animals. About 10,000 years ago we find the evidence of the first cultivation of cereal crops. It was in the mountains of Afghanistan, Anatolia and Abyssinia that the wheats were selected from among grasses by the primitive man. In fact these mountainous regions were the earliest cradles of civilization. In the mountainous area extending from Afghanistan to Caucasus originated the bread wheats, rye, most of the important legumes, Asiatic cottons, small-seeded flax, many oil-seed plants, onion, and almost all the fruits cultivated in the temperate parts of the world, such as the plum, apricot, peach, almond, cherry, apple, pear, grapes, walnut, strawberry, goose-berry, blackberry, etc. From these mountainous regions the river valley civilizations of Egypt, Mesopotamia, Sind and Punjab emerged in due course.

Abyssinia is the home of hard wheats, barley, millets, sorghums, sesame and coffee.

The country extending from the mountains of North-eastern India to Southern and Central China is the home-land of tea, soya-bean and citrus fruits.

The Indo-Malayan area is the home of banana, coconut, sugar-cane, mango and many other tropical fruits. Rice also probably originated in this area or perhaps in the Phillippines.

The countries bordering the Mediterranean on the North are the native home of oats, beet, figs, large-seeded flax, cabbage, cauliflower and other cultivated forms of *Brassica oleracea* and some legumes.

Finally, two centres lie in the New World, one in Central America, the second in the mountains of Tropical South America. Maize, potato, sweet potato, cassava, various varieties of field and garden beans, tobacco, tomato, chillies, squash, pumpkin, arrowroot, groundnut, papaya, pineapple, custard apple, guava, cocoa, cashewnut and sapota, etc. originated in these centres.

During the period of first cultivation of cereals, the domestication of sheep, goats, cattle and horses took place. About 8,000 years ago man started making pottery. The use of iron came about 6,000 years ago.

Pre-print of paper for Symposium on 'Science and the Nation during the Third Five Year Plan'.

We find a beginning of settled village and urban life in India about 5,000 years ago in Mohenjo Daro, Harappa, Rupar, Lothal and numerous other sites.

During that period the wheel had been invented. Metal working in copper, bronze and gold, and making of glass and basketry had been achieved. The people of this old culture cultivated land irrigated by annual floods of rivers. They grew wheat, barley and cotton of a coarse type and had short-horned zebu cattle, water buffaloes, camels and sheep as well as pigs and fowls.

Then came the Aryans from a region near the Caspian about 1500 B.C. They used an iron plough called *krish*, drawn by bullocks. In the field of agriculture the iron plough, and in battle-field bronze swords, and horse-drawn chariots established their superiority over the town dwellers of Mohenjo Daro, Harappa, Rupar etc. Their main cereal was barley. They had horses, cattle, sheep and goats. The horse was their sacred animal which they ceremonially sacrificed.

Earliest cultivation of rice was about 3,500 years ago in eastern India. This crop was selected from wild grasses which resemble the cultivated rice and are still to be found in Orissa.

The major technological and other changes, which came into play in Indian agriculture since then, are plant introduction, irrigation, plant breeding, use of fertilisers and pesticides, and use of electric motors, pumping engines and tractors. Before giving a full idea of the part played by these techniques, I would like to give a short history of agricultural research, education and extension in India.

Agricultural Research in India

Science has been a source of economic techniques for the last 150 years. The ripples of scientific activity reached India from Europe only in the last quarter of the nineteenth century. The recurring famines at last stirred the Government and it was the Famine Commission of 1880 which recommended that improved agriculture should be the main step for obtaining security against disastrous failures in food supply. As a first step, a Veterinary Research Institute was set up in Poona in 1889, later on shifted to Mukteshwar. The donation of an American philanthropist made possible the setting up of an Agricultural Research Institute at Pusa in 1905. This was followed by the setting up of Agricultural Colleges at Poona, Kanpur, Nagpur, Lyallpur, Coimbatore and Saboor. The Indian Central Cotton Committee was set up in 1921 and the Imperial (now Indian) Council of Agricultural Research in 1929. From 1931 to 1949, a series of Commodity Committees were set up to finance research on Jute, Sugarcane, Coconut, Oilseeds and Arecanut. This account shows that agricultural research in India is hardly 50 years old. The most important recent development is the setting up of Agricultural Universities at a number of centres in the country which, it is hoped, will not only stimulate research but also bring the results of research within the reach of cultivators more effectively.

Introduction of new crops

Bajra and sorghum were the earliest crops to be introduced into India from Africa. Grapes were introduced by the Muslim invaders from Iraq and Afghanistan about

1300 A.D. The Moghul Emperors, Akbar and Jehangir, who were garden lovers introduced chenar and poplar in Kashmir from Central Asia and cherries from Kabul. However, the greatest impact on the agricultural economy of the country was made by the Portuguese in early 17th century. They came to India in their sailing vessels in search of spices like black pepper which were used for preservation of meat in Europe. India is indebted to them for the introduction of many new crops from the New World. They introduced tobacco, groundnut, potato, sweet-potato, maize, papaya and pine-apple in early 17th century from America. Tomato, which was introduced by the Spanish explorers in Europe in 1535, reached India late in 18th century. With the ascendancy of the British in the 18th century, their East India Company assumed the role of plant introducers. They introduced tea, Lichi, loquat from China and vegetables like cabbages and cauliflowers from Europe in the last quarter of the 18th century. A recent example of plant introduction of significance is that of Ridley wheat from Australia in Himachal Pradesh where it has given good yields.

Irrigation

The earliest irrigation system in India was the Grand Anicut built across the river Cauvery in South India in the second century A.D. This was followed by building of large tanks in South India as well as in Rajasthan from the eighth century onwards. Canal irrigation in North India was introduced by the Muslims and the Western Jamuna Canal was constructed in the 14th century by the Tughlaks. The total area under irrigation in the country was only 3 million acres till 1850. After that the British started a series of irrigation works and before they left, 49 million acres were irrigated, out of which 15 million acres were by canals.

Since Independence, irrigation has been expanded by building as many as 19 dams. In the First Plan, 14 million acres of land were brought under irrigation. The Second Plan provided for additional irrigation of 21 million acres. At the end of the Third Plan, there will be 100 million acres of irrigated area in India. As against this, the ultimate potential of all irrigation schemes—major, medium and minor—is estimated at 170 million acres. This shows the enormous potential of irrigation which still requires to be tapped, and this is the main hope of Indian agriculture.

CONCENTRATE RESOURCES FOR IRRIGATION OF AREA IN OUR ARID ZONE

Irrigation by canals is most rewarding in the arid zone of India. Irrigation provided by such means in areas with assured rainfall in eastern India has largely remained unutilized. As such it is in the interest of the country that sizeable resources are invested for providing irrigation in the arid zone where it can be most rewarding. Moreover, this is also the area which on account of its freedom from excessive rainfall during the flowering period of cotton is ideal for its growing, and will give the additional cotton which India requires.

Contribution of Plant Breeding to Indian Agriculture

The microscope became a workable tool in the close of the 18th century. In the first quarter of the 19th century the structure of plants was discovered. It was established that the plants have male and female reproductive cells as in animals. About a century ago Mendel discovered the laws of heredity. Plant breeding work in India started in the early part of this century. The earlier work was by British scientists like Barber on sugarcane and by Howard on wheat. Indian scientists came into the field of research from the second decade of the present century. The sugarcane breeding work by T.S. Venkataraman at Coimbatore provided the base for the sugar industry of India. Today over 90 per cent of the total sugarcane acreage has Coimbatore canes and production has increased by at least 50 per cent as compared with the older cane varieties. The American cottons were introduced by the East India Company in the first half of the 19th century in Punjab, Gujarat and U.P. In 1902 Punjab *Narma* was grown in Shahpur district. Labh Singh gave the L.L.S. cotton to Punjab. Many improved varieties have been evolved in Gujarat, Maharashtra and Madras. The work of Iyengar at Coimbatore on millets, and of Ramiah on paddy is also outstanding.

The selections of wheat made in Punjab at Lyallpur by Ram Dhan Singh gave us wheat of good quality. The new Pusa varieties evolved by B.P. Pal at the Indian Agricultural Research Institute resistant to all the three rusts is a remarkable achievement. The development and release of maize hybrids with the aid of Rockefeller Foundation in the period of last six years has demonstrated rapid increase in production which can accrue from a coordinated and integrated approach to plant breeding. These hybrids are capable of giving 30 to 50 per cent more yield than the local varieties. It is our paddies which require more attention. The defect with our paddies is that their intake of fertilizers is low. A programme of producing *Japonica Indica* hybrids of paddy is in progress since 1950. Some promising selections are under extensive tests. When released for general cultivation these are likely to make impact on the production of paddy.

India requires more Fertilizers to feed Nitrogen Hungry Soil

While the use of organic manures is possibly as old as agriculture, inorganic fertilisers came into use only during the last 100 years. The pioneer was Liebig, a German chemist, who propounded his theory of mineral nutrition of plants in 1840. The role of nitrogen in plant nutrition was fully established only in 1857 by Lawes, Gilbert and Pugh at Rothamsted. The year 1910 is an important event in agriculture when German chemists evolved economically feasible methods of fixing atmospheric nitrogen. After the conclusion of World War I, this industry grew in different parts of the world and now nitrogenous fertilisers in various forms like ammonium sulphate, ammonium nitrate, urea, etc. are being produced on a large scale.

In India the use of fertilisers was first initiated in 1896 when imported Chilean nitrate was used as a fertiliser. During 1920-30 the Imperial Chemical Industries carried out experiments on different crops particularly paddy with the application of ammonium sulphate and its superiority over other nitrogenous fertilisers was established. The manufacture of ammonium sulphate was started in Mysore in 1938 and later on in Kerala in 1947. The factory at Sindri was started in 1951, at Nangal in 1961 and at

Rourkela in 1962. The production and use of nitrogenous fertilisers as it has grown, is given below :—

	Nitrogen (tons)		
Year	*Produced*	*Imported*	*Consumed*
1951	10,500	20,800	58,700
1956	77,000	55,500	97,624
1960	131,576	95,000	229,500

On account of cultivation for a long period Indian soils are at a very low level of fertility. There is almost a universal need for nitrogen. About 75 per cent of the soils are deficient in phosphorus and 25 per cent in potash.

The total irrigated area in India is 68 million acres. Area under assured rainfall is about 82 million acres. Present production of fertilisers is adequate for only 11 million acres. This indicates that in the Fourth Plan the production of fertilisers should be 3.65 million tons of N, P and K put together.

It has to be borne in mind that 25 per cent of the increase in crop yields in U.S.A. in the past 12 years has been due to the use of fertilisers. The potential economic use of fertilisers is 5.4 million tons of nitrogen and 2.7 and 1.3 million tons of phosphoric acid and potash. The use of these quantities of fertilisers would increase crop production by 70 million tons of foodgrain equivalent. It is necessary that this should be achieved during the next two Plan periods.

The need for phosphate and potash fertilisers has not been adequately recognised. This imbalance should be corrected in the interest of agricultural production.

The price of fertilisers produced in India is Rs. 1837.00 per ton of N while the world price is Rs. 1100.00 to Rs. 1450.00. The high cost of fertilisers is one of the main hurdles which prevents its wider use. The domestic price of fertilisers should be reduced to more near the world price.

Apart from directly resulting in increased crop yields the use of fertilisers is one of the channels for introducing scientific method and change. Fertilisers give best results with improved seeds, good soil and water conservation and proper tillage. Thus the use of fertilisers is one of the important methods of modernising agriculture and introducing scientific technology in crop production. The agricultural revolution of the 20th century is largely based upon a more complete understanding of plant nutrition which has led to greater use of fertilisers. We should liberally make use of the nitrogen of the atmosphere through the medium of fertilisers in increasing our crop production.

Organic manures

Organic manures are necessary for soil fertility but they are no subtitute for fertilizers. Good production requires both chemical fertilizers and organic manures, and hence we should aim at increasing the production of both and waste no time in futile controversies regarding their respective merits.

1. ENCOURAGE HOME-STEADING, PLANTING OF SHELTER BELTS OF TREES AND BIOGAS PLANTS TO ENSURE BETTER UTILIZATION OF VILLAGE WASTES

If we could encourage home-steading, particularly in North India, i.e. the practice of the farmers living on the land which they cultivate, there would be more effective utilization of cattle dung, urine and human wastes. We should also encourage planting of *shisham*, *babul* and eucalyptus trees along the field boundaries as shelter belts so that cattle dung is not used as fuel and goes to the fields as manure. Use of biogas plants for cooking is another manure saving device.

2. UTILIZE URBAN WASTES MORE EFFECTIVELY

Fertilizers give best results in combination with bulky organic manures which improve the texture of the soil and also promote microbial activity. It is in the countries of the Far East such as China and Japan that effective use of human wastes is made. In our country, however, these wastes are not effectively utilized. A study carried on by the Committee on Natural Resources, on urban wastes has revealed that while the potential capacity for compositing of urban wastes is about 78 lakh tons, actual production is only 29 lakh tons. That too contains broken glass and pieces of tin which are a menace to the feet of bullocks. Mechanical sieving is an urgent necessity near the manure dumps of large cities. In addition, out of about 700 million gallons of sewage and sullage available in the urban areas only 200 million gallons are used, the remaining being discharged into rivers and streams. Sometimes these wastes take place as there is no land available close by on account of lack of forethought by the town-planners. In the next Plan we should take steps for the full utilization of these wastes, and in future planning of our cities we should see that adequate areas are left unbuilt for sewage and sullage farms.

3. EXTEND THE USE OF GREEN MANURES

Sivaraman has done great service to Indian agriculture by emphasizing the use of green manures for building soil fertility. The use of green manures is quite a common practice in South India though it has hardly made a serious impact in North India. Sann (*Crotalaria Juncea*), *Sesbanea sp.* (*Dhaincha*) and *guara* (*Cymopsis tetragonoloba*) are useful green manure crops. As green manuring with these crops means the loss of one crop, only farmers with substantial holdings can afford it. One of the incentives for popularising green manuring is the supply of free canal water wherever it is available for the green manure crop. This is a concession which is well-worth extending as green manuring gives an average additional production of 2.5 maunds of grain per acre.

4. RAISE AVENUES OF GREEN MANURE TREES IN PADDY AREAS

Leaves of trees, particularly *Pongamia glabra* and *Gliricidia maculata* are highly beneficial for paddy. It is desirable that double avenues of these trees should be raised along the road-sides in all the rice-growing areas in southern and eastern India. These avenues should be permitted to be lopped in rotation by the farmers. A programme of this nature should figure prominently in the forestry and road-side avenue planting schemes of the southern and eastern states. Farmers should also be induced to plant these trees in the form of shelter belts around their fields.

Manufacture adequate quantities of Pesticides and Weedicides

1. PESTICIDES

The loss caused to crops by insects and other pests is enormous. With the increase in yields through use of fertilisers, good seeds and improved agricultural practices, it is very necessary that they are protected from insects and crop diseases. Such protection should be given in the fields and also in storage. This means that in the next Five Year Plan we should make adequate provision for the development of plant protection industry, viz. manufacture of chemicals as well as equipment at an adequate scale to meet the requirements of Indian agriculture.

2. WEEDICIDES

Weedicides have great potentiality in increasing food production. In eastern Punjab and western U.P. almost 20 per cent of the wheat crop is lost because of the pernicious *pohli* weed. The weedicide known as 2-4-D has proved effective against *pohli*. This is the latest weapon which science has provided from its armoury to aid crop production and we should encourage manufacture of weedicides in India.

India requires more tractors than cars

On account of the imposition of ceilings on land holdings to the level of 30 acres, use of large tractors is not economical. It is, however, possible to use small tractors of 10—20 horse power on many farms. They can replace bullocks and release the land used for fodder crops for growing food crops. Small tractors are necessary for efficient and timely farm operations which can contribute substantially to increasing agricultural production. Timely cultivation is particularly necessary after the close of the monsoons when the soil is to be prepared for the cultivation of wheat and moisture must be conserved in a short period. Many improved practices such as inter-cultivation, control of space and depth in sowing of seeds and placement of fertilizers cannot be adopted with bullock cultivation. Moreover, wastelands in the riveraine tracts which quickly get covered with grass can only be conquered by the tractor. The use of tractor also eliminates the back-breaking drudgery of bullock cultivation.

Use of machine in agriculture demands higher intelligence and skill and makes agriculture a pleasant profession. This is also one of the avenues for solving the problem of the educated unemployed in the rural areas, and at the same time it extends the adoption of scientific technique in agriculture. In 1956 there were only 20,980 tractors in agricultural use in India which works out at one tractor for 7300 hectares of arable land. In U.K. there is one tractor to every 9 hectares of arable land. In Japan it is one tractor for every 6 hectares.

The use of tractors would also promote cooperative farming which is practically impossible with bullock cultivation. Only the introduction of a new technology can promote a social change in the use of land. Among the many factors which led to the failure of the Communes in China is the continuance of old implements. Compare the success of Japanese agriculture on the other hand, which is largely due to the use of small tractors and large number of improved implements by the small farmers with the entire family working in the fields.

If one examines the progress of agriculture in countries like Japan and U.K., the impact which mechanisation has made on agricultural production is evident. Here I would like to quote from a recent study of Japanese agriculture by Hall.

"Japan is now in another stage of its agricultural revolution—the replacement of manual labour with machinery. The use of power hullers, threshers, polishers, mechanical water lifts, small motors, power sprayers, engines to power pumps, and numerous other mechanical implements is common in all parts of Japan. The most recent and spectacular development has been the remarkable popularity and expansion in the use of hand tractors, or power cultivators—3 to 7 horsepower machines much like rototillers. In 1947 there were 7,000 in use, 35,000 in 1953, 85,000 in 1955, and estimates for 1961 run as high as 1,000,000. These machines are used to cultivate the land and take the place of the work animal and plow. They can be used in both wet and dry fields and constitute a major technological breakthrough in paddy cultivation. They are light, easy to handle, and much faster and more powerful than animal-drawn plows. In addition to cultivation, the machines can be used for powering pumps, threshers, and saws, and they can be fitted with special attachments such as trailers, sprayers, and fertilizer spreaders."

"With a hand tractor a farmer can do as much in one day as he can by using animal power in ten days. This extra time lengthens the growing season, gives the farmer much more flexibility in his farming operations, and has made it possible to plant more land with a second crop. The use of these machines has also released time for work on such things as road improvements and the development of pasture lands and orchards and has made it possible to substitute animals for milk and meat production for draft animals".

"The success of the Japanese farmer in raising farm productivity to such high levels by combining intensive agriculture on small farms with modern technology and new machinery gives promise of a major agricultural revolution in countries all over the world. Many have feared that the use of machinery would, while increasing worker productivity, lowers yields per unit of land. Perhaps the major significance of the Japanese agricultural mechanical revolution is that it has helped to raise both the productivity of manpower and of the land."

The moral is obvious. What India requires is more tractors and fewer cars.

Mechanised family farms linked with the markets of urban areas through an efficient system of co-operative marketing is the ideal which we should aim at to bring prosperity to our villages and for raising agricultural production.

It is only in this manner that we will be able to liquidate the vast slums sprawling over our country-side.

REDUCE CENTRAL DUTY ON DIESEL OIL USED FOR AGRICULTURAL TRACTORS AND VILLAGE PUMPING SETS

The price of high speed diesel oil used for agricultural tractors and of low speed diesel oil for village pumping sets has more than doubled since 1951 as indicated in Table A.

This shows that the cost of cultivation and irrigation by mechanised means has greatly increased. This is a great disincentive to agricultural production. It is easy to calculate the requirement of each user and to give him proportionate rebate in duty which can be approximately worked out on acreage basis cultivated and irrigated. We should take this step early if we are not to give a major set-back to agriculture.

Table A

Selling Prices of diesel oil. F.O.R. Bombay

	High speed diesel oil used for agricultural tractors (Rs. per gallon)		*Low speed diesel oil used for village pumping sets (Rs. per ton)*	
		Duty		*Duty*
1.10.1951	0.95	(0.19)	202	(23)
1.4.1957	1.19	(0.44)	248	(55)
2.3.1963	2.68	(2.04)	418	(234)

Tap the Resources of the Sea more effectively for feeding our mounting population

The productivity of the sea is estimated to be equal to that of land. It is by tapping the fisheries of the Pacific and the Indian Oceans that Japan has been able to support such a large population. It is the marine fish and crustaceans along with the new crop of Tapioca which has saved the over-populated Kerala from starvation. India, with its coast line of 3530 miles and a continental shelf of more than 10,000 square miles, has vast potential of marine fish, molluscs and crustaceans which can be caught. While India's need is estimated at 4 million tons the catch is less than a million tons. With mechanisation of boats, food from this source can be greatly increased. This also underlines the necessity of manufacturing more diesel motors and building cold-storage along the coastal area, particularly in Kerala and Madras.

Give high priority to Refrigeration Industry

During the current plan as well as in the Fourth Five Year Plan the production of potatoes, fruits, fish, meat and poultry is closely connected with the development of refrigeration industry. Locate a cold store in a particular area which is suitable for the growth of potatoes and you immediately notice that potato cultivation spreads. This is largely due to the fact that the price of potatoes fluctuate greatly. While the farmers get hardly a reasonable return at the harvesting season, prices rise after a few months. Cold storage evens the fluctuation in prices. Out of all the crops potatoes are the highest yielders of food and their cultivation also creates employment for a large number of people.

The success of poultry farming in Punjab has largely been due to location of deep-freeze units and refrigerators at a number of centres where eggs as well as meat can be stored. Similarly for apples and oranges cold stores have proved a boon and they are now available throughout the year. Hence, cold storage should no longer be regarded as a luxury. It is most essential for the development of the crops, I have mentioned, as well as for fish and poultry. It is particularly necessary in a tropical country where the process of rotting starts in a short time.

Future Progress of Agriculture dependent upon Ancillary Industries

From the review which I have given it is evident that further progress of agriculture, the major industry of India, is closely dependent on progress of certain ancillary industries. In chemical industry we have to give the closest attention to the manufacture of fertilisers, pesticides and weedicides. The manufacture of pumping sets, electric motors, diesel engines, power tillers and tractors has to be on a much larger scale. Refrigeration industry on which progress of many schemes is dependent, requires to be developed on a much more ambitious scale. We have to make a clear choice between scientific agriculture based on modern technology and primitive agriculture based on animal power. Besides we have also to shed our irrational prejudices against the use of meat, fish and eggs which contain a high content of proteins.

Science News

Selective Weedkiller

A new selective weedkiller for cereals, said to be effective against an exceptionally wide range of weeds, has reached the farm trial stage in Britain and is expected to be available for use in 1965. It is unusual in combining strong contact activity with a moderate degree of systemic action quite different from that of the existing cereal herbicides. It therefore destroys in two ways—by direct contact with the plant and by absorption through the plant's roots—and kills much quicker and more completely than the growth-regulator herbicides. Yet, in contrast to the dinitro phenol contact weedkillers, it is fully effective and selective at low volumes —15-20 gallons per acre.

Field experiments with about 30 varieties of wheat, oats and barley have shown a very high degree of selectivity. Not only has the yield been unaffected by applications of at least three times the weedkilling rate, but no signs of deformity have been found in many thousands of plants and ears examined after spraying at growth stages ranging from two-leaf to jointing.

Investigations into the safety of the weedkiller as it relates to users, consumers and wild life, are in progress, and results so far, particularly the evidence of short persistence in crops, are reported to be encouraging.

(*Brit. Inf. Ser. BF 523*)

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"Electro-Painting"

A paint process has been developed for car bodies that will substantially reduce the risk of corrosion and improve the over-all quality of vehicle bodies.

The new process—known as electrocoating—is being used by Ford of Britain to give a primer coat to two of their current range—Anglia and Corsair—in production at their new Halewood plant in North-West England. All models will be treated in the same way within the next two years.

The new process, which replaces conventional primer spraying and dipping processes, is essentially a dipping operation in which an electric current is passed between the car, completely immersed in a tank containing thousands of gallons of paint, and a second electrode. As the body submerges, electrical contact is made and paint particles cling to it, quickly building up an even coating over all surfaces.

(*Brit. Inf. Ser. BF 678*)

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Miniature Electric Motor

A precision-made industrial electric motor, just one inch in diameter and just over two inches in length, has been produced to bridge the gap between expensive miniature servo motors and toy motors. Made by a British firm it is rated at one thousandth of a horse power. It weighs 1.3 oz.

The firm says that the prototype was tested by the Royal Aircraft Establishment at Farnborough, and proved to have a life of some 300 hours before the brushes needed changing.

The motor has sintered bronze bearings and carbon brushes similar to those used in the more powerful ranges of motor. Torque is rated at 20 gm. cm. at 5,000 r.p.m., which is normal running speed. The current at 12V is 300 milliamps on load.

Models are available in one-and-a-half, six and 12 voltages. The bearings are self-oiling with ball bearing thrust.

(*Brit. Inf. Ser. BF 105*)

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Plastics Covering for Pipe Insulation

A new type of plastic jacket for insulating pipes before use underground has been developed in Britain.

Intended for pipes that are to carry water, oil, grain, or other substances needing a constant temperature, the jacket is applied in two stages. First a waterproof polythene outer layer is wrapped loosely around the pipe. Foam polyurethane able to withstand temperatures between minus 50°F and 240°F is then injected into the cavity between polythene and pipe.

When the pipes are laid they are joined by an oversize polythene sleeve into which polyurethane is injected from mobile equipment.

The makers of the jacket claim that by removing the need for brick or concrete pipe ducts the system reduces installation costs. They also supply pre-insulted pipes to any specification.

(*Brit. Inf. Ser. BF 78*)

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Revolution in cane farming

A new strain of sugar cane likely to revolutionise sugar cane cultivation in India has been evolved in the Coimbatore Sugarcane Research Station. This strain, called 740, is claimed to have given very high yields of the order of 130 tons per acre. One agriculturist of Poona is reported to have had a record yield of 238 tons per acre. The recoverable sugar content of the 740 variety is 12—13 per cent.

Agricultural Production in the Past Decade and its Future Prospects

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Abstract

The agricultural production in India has been raised in the First and Second Five-Year Plan periods as envisaged. The stage of take-off has arrived. The next essential step is to stabilize agriculture *vis a vis* industrial production for balanced growth of economy in the country. Development in agriculture at a faster rate and in a sustained manner with less influence of environmental factors is essential to meet the needs of growing human population and increasing concentration of population in urban areas, to provide raw materials for the expanding agriculture based industries, to secure working capital for non-agricultural development by exporting raw materials and finished goods to earn foreign exchange, and to raise agricultural incomes for reinvestment and increase resources in rural areas to finance large scale rural development in the fields of housing, rural sanitation, water supply, education, rural health and so on.

The results have shown that there is need to supply fertilizers, seeds, irrigation, implements and machinery, and pesticides on an increasing scale. For these, development of industrial infrastructure is very essential. This should receive very high priority otherwise the seasonal vagaries will continue to influence production as is evidenced by the production in the first two years of the Third Five Year Plan. The technology can only be effective if these materials and services are available at reasonable cost to the farmers. The organisation of intensive agriculture based upon developing individual farm plans in 80 districts of the country with ancillary services is a step in the right direction. The reinvestment of a greater proportion of the net income of the farmers is most essential to bring about positive permanent improvement in production of crops.

Introduction

Historically the development of agriculture started as early as 1875 when the first Famine Commission was appointed. During the next three decades the emphasis was on the extension of irrigation facilities in dry areas of the country. It was in 1906 that the foundation of pioneering research and teaching was laid when the Indian Agricultural Research Institute and a chain of Colleges of

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Agriculture and Research Stations were set up. The main provincial centres of research were started at Coimbatore, Kanpur, Lyallpur, Nagpur, Poona and Sabour. Simultaneously the Indian Agricultural Service was instituted which very much helped in furthering the cause of research, education and extension at the Centre and in the States.

In the following four decades the principal emphasis on research was on selection and breeding of improved varieties of crops, systematic study of pests and diseases and their control, cultural and manuring trials in State farms, trial of introduced implements, tractors and tractor machinery, soil analysis and pre-irrigation soil surveys and animal nutrition and nutritive value of feeds and forages and water requirements of crops with the limited resources for extension of the results of researches. Upto 1930 the extension activity was confined to district headquarters with limited activity at the Taluqa or Tehsil centres. The contacts were restricted to landlords and a few progressive farmers.

With the setting up of the National Government at the Centre and in the States in 1946, the tempo of agricultural development began to be stepped up. The 'Grow More Food' Campaign, started in 1943-44 after the Bengal Famine, was reorientated into intensive agricultural development programme under the revised policy with emphasis on community projects. The objective of this policy was to expand production and create adequate purchasing power to increase consumption and improve health of the people through proper nutrition[1]. The First Five Year Plan of economic development was launched in 1951-52. The decade ending in 1961-62 has been a significant one when firm foundation for higher production of agricultural commodities was laid by introducing technology on a mass scale.

The period prior to 1906 is characterised by traditional agriculture, 1906 to 1951 the period of the precondition for take off, and 1951 to 1961 the period of take-off stage. In fact in the present stage of agriculture all the three stages are inherent but by and large the take-off stage is prevailing over the other two[10].

Need for Rapid Development

In India 70 per cent of the population is still dependent on agriculture and occupations ancillary to agriculture. The rate of increase of population in rural India is higher than in the urban parts and amounts to 2.3 per cent per annum. There is a trend in migration of people to urban centres where they entirely depend upon food produced in predominantly agricultural areas. The urban population has higher incomes. The expanding population needs larger quantities of food. At the beginning of First Five Year Plan the rate of consumption of food grains averaged 13 oz. At the end of Second Five Year Plan it rose to 17 oz. per capita. It appears that this rate is not likely to exceed very much in the coming years. But the tempo of food production must be maintained to meet the food requirements of the growing population and for increased rural requirements where the rise of income has been manifested in recent years.

Secondly, the traditional exports from India have largely comprised agricultural raw materials and recently also processed goods based on agricultural based industries. These are cotton textiles, jute manufactures, tea, coffee, rubber, oils and oil cakes, sugar and *gur*. During 1960-61 agricultural commodities accounted for 78 per cent of the exports as against 33 per cent of the imports of similar commodities. The latter consisted largely of long and medium staple varieties of cotton costing Rs. 85 crores. The agricultural based industries will continue to expand to meet the requirements of the expanding internal market, for sustaining the tempo of exports in order to earn foreign exchange. This emphasises the need for expanding production of commercial crops.

Thirdly, in a rural economy the capital for non-agricultural development must largely come through agricultural expansion. In the take-off stage the requirements of the fixed capital are very large. The industries cannot expand on their own earnings. They need capital from outside resources.

Fourthly, the expanding small, medium and large scale industries require ample labour. This can only come from the agriculture sector. Unless per acre yields are stepped up and peasant farming is converted into commercial agriculture i.e. capital intensive rather than labour intensive agriculture, the industries would continue to suffer from high wage bill which is disincentive to expansion in the industrial field. Fortunately the saturation limit has not yet been reached and the general policy is to expand the industrial sector to absorb the surplus labour force.

Fifthly, the need for expansion of agriculture is vital to rural development. Unless the agricultural incomes are raised the reinvestment in agriculture for stepping up crop production and raising by-products of animal husbandry would continue to suffer. In fact the per acre yields of crops have increased marginally in the past decade because of low capital reinvestment in agriculture. The investment has been largely in irrigation which has almost entirely been financed from Govt. revenues. The tax revenues from the rural sector are very small even today. In consequence the rural development is still lagging behind. In spite of the initiation of Panchayati Raj, the rural development has lagged in pace as resources are limited for expansion of social security, secondary and technical education, rural health and sanitation, electrification and rural amenities.

Sixthly, there is still a lack of balance between growth of agricultural and industrial sectors. The technical assistance to agriculture is not of a high order. Modern science and technology have yet to play a significant role in both the production methods and the standards of welfare of the rural life and social development. A recent survey by the Federation of Indian Chambers of Commerce and Industry indicates that there has been a widespread growth of organised industries in India during the first decade of planning. The output of private organised industries and mining has nearly doubled. The capital goods and producer goods industries have simultaneously expanded. In 1950-51 the output of these industries in both private and public sectors amounted to Rs. 1,545 crores. It rose to Rs. 3,198 crores in 1960-61. The expansion has occurred in base metals and products, transport equipment, machinery, electrical equipment, chemicals and pharmaceuticals, mining and oil, non-metal minerals, rubber and leather products, paper and wood products and textiles and food products. In this period the private sector undertook about 50 per cent of the national investment and produced 80 per cent of the additional income. Rs. 400 crores were invested by the private sector in the development of village and small scale industries. In the development of industries modern technical knowledge has been employed on an intensive scale from indigenous resources as well as by foreign collaboration. The contribution of agriculture to national income during 1962-64 was 38.6 per cent (at 1948-49 prices). The average for the period 1950-51 and 1960-61 was 40 per cent as against a stipulated requirement of 50 per cent for proper balance between agricultural and industrial sectors. The savings for reinvestment have been less by 20 per cent.

Seventhly, if agriculture is developed at the same time as the industry, the rural communities provide an expanding domestic market for industrial goods. Their cost is reduced and they become competitive in the foreign markets. On the other hand the industrial workers provide market for the agriculturally high value products such as milk, butter, cheese, eggs, meat, vegetables and fruits. In several developing countries over-emphasis is laid on industrial development. The consequence is that it caters to a small upper middle class existing in urban areas. Industry cannot work to its full capacity. This slackens the pace of industrial development as profits are not high enough to be reinvested in expansion.

Lastly, the agricultural development must aim at high rate of production per acre. About 80 per cent of the cropped area is under food crops. Part of it must be released for production of commercial crops for meeting the increasing requirements of consumer industries. The ratio must be progressively narrowed down. As in the U.S.A. this has to be achieved by intensive development.

Causes of Stagnant Production in the take-off stage

In the first two Plan periods the agricultural production expanded as a consequence of three operating causes. These were (a) expansion of cropped area from 276 to 326 million acres. (b) more of favourable than unfavourable weather years, and (c) increasing inputs of expanding irrigation facilities, fertilizer programmes, seed supplies, rural credit and so on. During this period the agricultural production increased on the average at the rate of 4.5 per cent per annum.

In 1961-62 the agricultural production increased by 1.2 per cent and in 1962-63 it declined by 3.3 per cent. The output of rice was reduced by 8 per cent and of wheat and sugarcane by 7.5 per cent each. Cotton production showed a slight improvement over the previous year. The chief causes for reduced production are (a) unfavourable monsoon, (b) diversion of funds to other programmes, (c) low priority given to agriculture, (d) inadequate financial Plan provisions, and (e) lack of administrative co-ordination. Of all these, the most important is the weather factor. The shortage in rainfall during September can reduce production of food grains by as much as 1.5 million tons. The overall effect of unfavourable weather can be loss of foodgrains by 4 million tons.

In 1961-62 minor irrigation provided water to 1.67 million acres as against the

Plan target of 12.8 million acres (in 1965-66) and the area which benefitted from soil conservation increased only by about a million acres compared to Plan target of 11 million acres (in 1965-66). The utilization of irrigation potential is now 79 per cent of that available from major irrigation projects. The total supply of nitrogenous fertilizer assumed to be available was 400,000 tons as against the actual which was 296,000 tons. The supply of fertilizers in 1962-63 is estimated at 404,000 tons of nitrogen against the original target of 525,000 tons.

Effective Factors for Stabilizing Agriculture

It is now realised on all accounts that agricultural production is of strategic importance and on its stabilization depends the economic and industrial development of the country. This instability can be overcome by several measures which have a technological basis. The relative effectiveness of these factors is discussed as under :—

1. *Soil Fertility* : As already stated the yield of crops is largely controlled by the level of fertility of the soil. The relative water requirements of crop is high when the soil is low in fertility. Alternatively the most efficient use of water occurs when the fertility level of the field is high. A soil high fertility index when all the major and minor nutrients are fairly freely available for crop production, the soil reaction is normal and the salt concentration is low. In recent years a large number of fertilizer trials have been conducted in the cultivators' fields[3,4]. The data of these trials are summarised below :—

Table 1

Economics of Fertilizer Use in simple Fertilizer Trials on Paddy

(Percentage net return on investment is given in brackets).

Fertilizer treatment	No. of Expts.	Cost of Fertilizers (Rs.)	Response md/acre	Value of response at paddy prices (Rs./md)			Net profit at paddy prices (Rs./md)		
				10	12	14	10	12	14
20 lbs N	1,596	17	4.5	45	54	63	28 (165)	37 (218)	46 (271)
40 lbs N	780	34	6.6	66	79	92	32 (14)	45 (132)	58 (171)
20 lbs P_2O_5	860	15	3.6	36	43	50	21 (140)	28 (187)	35 (233)
20 lbs N + 20 lbs P_2O_5	1,784	32	6.6	66	79	92	34 (106)	47 (147)	60 (188)
40 lbs N + 20 lbs P_2O_5	965	49	7.9	79	95	111	30 (61)	46 (94)	62 (127)
20 lbs N + 40 lbs P_2O_5	674	47	7.8	78	74	109	31 (66)	47 (600)	62 (132)

Ammonium Sulphate @ Rs. 385 per ton ; Super @ Rs. 275 per ton.

Table 2

Economics of Fertilizer Use in simple Fertilizer trials conducted in Cultivator's fields on Wheat

(Percentage net return on investment is given in brackets)

Fertilizer treatment	No. of Expts.	Cost of Fertilizers (Rs.)	Response md/acre	Value of response at wheat prices (Rs./md)			Net profit per acre at wheat prices (Rs./md)		
				14	16	18	14	16	18
20 lbs N	1,191	17	3.0	42	48	54	25 (147)	31 (182)	37 (218)
40 lbs N	832	34	4.7	66	75	85	32 (94)	41 (112)	51 (150)
20 lbs N + 20 lbs P_2O_5	1,229	32	4.2	59	67	76	27 (84)	35 (108)	44 (138)
20 lbs N + 40 lbs P_2O_5	398	47	5.2	73	83	94	26 (55)	36 (77)	47 (100)
20 lbs N + 20 lbs P_2O_5	760	49	5.9	83	94	106	34 (69)	45 (92)	57 (116)

In case of paddy and wheat the application of nitrogen and phosphate individually and in combination at all levels have shown very high net profits at various price levels. High doses of fertilizers particularly of phosphate give high residual response. This has been exhibited in various experiments the results of which have been summarised by Raheja & Bains[8] (1960). Some of the data are given below :—

Table 3

Average Direct and Residual Response Net Profit and Apportionment of Fertilizer cost in paddy-paddy rotation

Particulars	20 lbs P_2O_5/acre		40 lbs P_2O_5/acre	
	Direct	Revised	Direct	Revised
Mean extra out turn—md/acre	3.96	2.16	4.90	3.43
Cash value of the extra produce at Rs. 12.00 per md of paddy (Rs.)	47.52	25.92	58.80	41.64
Cost of fertilizer per dose at 0.61 per lb of P_2O_5 (Rs.)	12.20		24.40	
Net Profit (Rs.)	61.24		76.04	
Percentage cost of fertilizer chargeable to fertilized and residual crops	64.70	35.30	58.54	41.46
	Direct		Residual	
Average percentage cost of fertilizer chargeable	61.62		38.38	

On an investment of Rs. 12.20 the net profit realised was Rs. 61.64 and when the investment was increased to Rs. 24.40, the net profit realised was Rs. 76.C4. Thus phosphate abplication built up the soil fertility.

The results of trials conducted under rainfed conditions in the Malwa tract of Madhya Pradesh have indicated that the relative response to fertilizer nitrogen goes on increasing as the fertility of soil increases (Panse *et al.* 1951). The data are summarised as follows :

Table 4

Responses to various Levels of Nitrogen at different Soil Fertility Levels in Cotton

Level of Soil fertility	Average yield of cotton lbs/acre	Yield without nitrogen lbs/acre	Response to doses of nitrogen (lbs/acre)				
			20	40	60	80	100
Low	194	143	40	66	77	72	54
Medium	363	272	70	111	138	148	137
High	701	529	113	200	261	297	307

Under similar climatic conditions, the role of soil fertility played a dominant role in determining the rate of response to doses of ammonium sulphate. This analysis is based upon 70 experiments conducted in fields of various levels of fertility.

The application of phosphate to soil for the berseem crop gives a high response in extra fodder yield. It also enriches the soil.

Table 5

Direct and Residual Response of Low Doses of Phosphate

Particulars	Levels of P_2O_5 applied to berseem (lbs/acre)		
	16	32	64
Extra yield of berseem green fodder (mds)	138.9	220.5	319.1
Extra yield of berseem seed (mds)	1.41	2.23	2.48
Extra yield of wheat grain in mds. due to residual effect of phosphate	1.80	3.00	6.80
Extra yield of wheat *Bhusa* in mds. due to residual effect of phosphate	3.60	6.00	13.60
Investment of fertilizers	Rs. 9.26	19.52	39.04
Net profit due to phosphate fertilization	Rs. 270.89	428.23	602.06

On application of phosphatic fertilizer the berseem crop fixed nitrogen in the soil. There was also some residual phosphorus available from the utilized phosphate. The two together built up fertility reserve so that the succeeding crop of wheat was appreciably benefitted at 16.32 and 64 lbs P_2O_5 levels and the net profit realized was enormously high.

These results illustrate that the responses to fertilizers are very high. The fertilizers, like organic manures, build up soil fertility. As the soil fertility is built up the response to repeated applications increases successively. By this process the yields are stabilized and are less subjected to seasonal fluctuations.

2. *Irrigation and water conservation* : The responses to irrigation are very high in dry areas. As the rainfall increases the benefit from the irrigation decreases. Irrigation is most essential in areas of less than 15 inches of rainfall, where crop yields are appreciated from 30-75 per cent. In the rainfall areas of 15-30 inches irrigation plays a protective role. The high water requirement crops or those sown in seasons when there is no precipitation, benefit appreciably. The other crops benefit to a small extent. The yield increases range from 10 to 40 per cent. In such regions soil fertility plays the dominant role and the value of water relative to its cost is very much stepped up. In regions of rainfall between 30 to 45 inches irrigation influences the yields marginally. But the response to fertilizer application is very much enhanced. Besides, benefit from weed and pest control is also very much increased.

The chief irrigated crops in India are wheat, sugarcane, long staple cotton, berseem, potato and maize. Rice is irrigated in those tracts where rainfall is low, but the areas are either flooded or water logged. Groundnut, *jowar*, bajra, linseed, sesamum and short staple cotton are largely grown under rainfed conditions.

There is an inter-relation between water supply and fertilizer application in relation to crop yields. In one of the studies the results obtained were as follows :—

Table 6

Effects of Rates of Irrigation and Nitrogen Levels on Yield of Maize

Bushels/acre.

Rate of irrigation	Levels of nitrogen—lbs/acre		
	60	120	240
36 acre inches	52	75	94
60 acre inches	55	106	130

The variety planted in this experiment was hybrid corn where water requirements are high. With high doses of nitrogen it was essential to increase supply of water so as to obtain high yields of 240 bushels (Raheja, 1961).

Similar experiments conducted in India have given the results as indicated in Table 7.

The average response to irrigation was about 45 per cent increase in yield of wheat crop. The level of responses under irrigation was very high compared to the responses derived under rainfed conditions. Thus the effectiveness of irrigation is substantially stepped up when supplemented with fertilizers.

The efficiency of irrigation can be substantially improved by adopting proper methods of irrigation. The experimental work on potato and other ridged crops has shown that by the furrow method of irrigation 15-20 per cent of the water can be saved as compared to flat check bed method of irrigation or wild flooding. For small grain crops of wheat, barley and oats, corrugated system of

Table 7

Effect of Nitrogen and Phosphate on Wheat grain Yield under Irrigated and Unirrigated Conditions

Levels of nutrients applied lbs/acre	IRRIGATED			UNIRRIGATED		
	No. of Expts.	Yield mds/acre	Response mds/acre	No. of Expts.	Yield mds/acre	Response mds/acre
Nitrogen level						
0		16.0	...		8.7	...
20	1,232	18.5	2.5	290	10.4	1.7
40		20.7	4.7		11.4	2.7
P_2O_5 level						
10		18.7	...		11.6	...
20	559	19.8	1.1	81	12.0	0.4
40		20.9	2.2		12.7	1.1

irrigation besides economising water by 10-15 per cent reduces lodging of crop. The level of fertilization can be raised in rich land. The crop can be dressed upto 60 lb N. whereas without corrugation wheat crop lodges with 40 lb N per acre. In the U.S.A. by irrigating in furrows and dressing high doses of nitrogen upto 160 lb per acre, yields of 4 bales of lint have been obtained. This is equivalent to 4800 lb of seed cotton as against an average of 1200 lb without furrow irrigation with optimum dressing of 60 lb of nitrogen per acre.

For even distribution of water, pre-irrigation development of land is very essential. In uneven fields the requirement of irrigation is high and in some spots which have low level, temporary water logging occurs which reduces the yield of crops. In an uneven field the stand of crop is generally not uniform due to defective germination in some of the patches which are either over-irrigated or have not received enough water. After preparatory tillage the land should be planked and levelled with a float to overcome unevenness. Thus a saving of about 2 acre inches is effected in the pre-soaking irrigation.

Where the cost of water is high, sprinkler system of irrigation substantially reduces the water cost. The experiments conducted at Indian Agricultural Research Institute have resulted in economy in water by 40 per cent for irrigation of crops of potato and tabacco. In Israel all the irrigation is applied by sprinkler system to economise the use of water (Raheja, 1961).

Water conservation in the rainfed areas can be brought about by bunding of the fields on the contour. The yields obtained on Black cotton soil of Manjari conducted for six years of Jowar crop in the unbunded and bunded were 965 lbs and 1,041 lbs respectively. At Raichur the extra yield obtained was 22 percent by bunding to stop the run off loss of water. The effect in the low rainfall years was more pronounced than in normal seasons. The actual data obtained at various stations were as follows :

Table 8

Yield of various Crops in the Bunding Series

(lbs./acre)

Crop	Research Station	Period	Mean Rainfall inches	Nature of Product	(Yield lbs/acre) Control	Bunded	Percentage increase
Sorghum	Hagari	1935-40	20.58	Grain	396	491	24.2
				Straw	1,243	1,325	6.6
Cotton	-do-	-do-	20.58	Kapas	288	330	14.7
Barley	Rohtak	1936-38	19.08	Grain	973	1,220	25.4
Gram	-do-	-do-	19.08	-do-	211	284	34.6

Quite appreciable increase in yield occurred due to bunding of the fields by impounding the water. This is one of the most important practices that can be adopted to stabilize agriculture in regions of water scarcity.

In order to increase the soaking or infiltration of water, harrowing particularly has proved very beneficial as it breaks the soil crust. The depth of stirring need not be more than 1 inch. The extent of advantage gained by harrowing at Sholapur was as follows :—

Table 9

Yield of Jowar from Plots receiving different Number of Harrowing

(lbs/acre)

Year	Rainfall inches	Harrowed once		Harrowed four times	
		Grain	Straw	Grain	Straw
1938-39	37.89	85	561	170	665
1939-40	14.89	28	75	18	413
1940-41	27.35	165	536	195	638
Mean	26.54	93	391	128	572

The plots harrowed four times in all the three years gave higher yield than plots harrowed once. Thus breaking of crust is an important operation to increase the penetration of water into the soil.

3. *Preparatory tillage and other field operations* : The experimental work throughout India has indicated that the land can be effectively tilled by indigenous implements as well as tractor driven machinery. The results of one of the experiments are given in Table 10.

Table 10

Average Yield of Wheat grain with different types of Cultivation Implements

Type of cultivation	No. of operations	Grain yield in mds/acre 1956-57	1957-58	1958-59	Mean
X Tractor implements	5	22.0	21.0	14.8	19.3
Y Board and *desi* ploughs	6	21.1	20.3	14.5	18.6
Z *Desi* ploughs	9	22.0	19.5	14.4	18.6
'F' test		not sig.	not sig.	not sig.	not sig.
SE_m		±0.5	±0.6	±0.4	±0.4

With tractor plough the alluvial soil at Kårnal was tilled to a depth of 9 inches and subsequently the land was prepared by 2 grubbings and 2 discings. The land prepared by bullock drawn implements in case of Y treatment was tilled to a depth of 6-7 inches and in case of Z treatment to the depth of 5 inches only. The number of operations was reduced in X & Y treatments. The economics of the treatments was calculated and is summarised as under :—

Table 11

Economics of Seed bed Preparation by different types of Tillage Implements

Type of cultivation	Cost of seed bed preparation Rs.	Value of Wheat Rs.	Net saving over Z treatment Rs.	Remarks
X. Tractor implement	39.50	318.45	+65.65	Tractor ploughing charged at Rs. 12, disc harrowing and grubbing at Rs. 5.50 each; ploughing with mould board plough at Rs. 10.00 and with *desi* plough at Rs. 8.00
Y. Board and *Desi* ploughs	79.60	306.90	+14.00	
Z. *Desi* Plough	93.60	306.90	...	

The cultivation with the tractor implements reduced the cost of seed bed preparation by Rs. 54.10 or approximately 58 per cent saving in cost (Relwani, 1961). Besides, the operations were performed in much less time. Under unirrigated conditions it is a distinct advantage particularly where large areas are to be covered and seasonal factors impede the performance of cultivation. The sowings completed in time raise the yield of crops.

The cost of sowing, inter-tillage, ridging, harvesting and threshing is also substantially reduced by use of power operated machinery.

Although the size of holdings in Japan is small, almost all the agricultural operations in production of various crops have been mechanised with the result that the cost of production is very much economised. In commercial crops of cotton, sugarcane, jute, groundnut, linseed and so on, the cost of production is high because of low level of yield and high cost of field operations. Consequently the processed goods cannot compete in the world markets. Sugar, textile, jute goods, rubber products, oils and oil products are all high priced manufactures.

4. *Weed Control*: Weed control can be effected by manually operated tools, bullock drawn implements, tractor tillers or by weedicides. In the cultivators' fields the experiments were conducted to control weeds by applying 2, 4-D at the rate of 1 lb in 60 gallons of water. The mean results of the trials are reported below :—

Table 12

Effect of 2, 4-D on Yield of Wheat

No. of fields	Treatment	Total fresh wt. of weeds per sq. ft. (Gm)	Grain yield mds/acre	Net profit Rs.	Remarks
6	Control	140.3	15.6	...	Cost of weedicide @
	2, 4-D	9.5	19.4	44.50	Rs. 3.06 per lb (80% a.e.)
	SE_m	±37.2	±0.046		sodium salt=Rs. 3.82
	't' test	Sig.	Sig.		Cost of hand spraying= Rs. 4.00. Price of wheat per md=Rs. 14.00.

The cost of spraying the weedicide was Rs. 7.82. Against this, manual weeding cost ranges from Rs. 16 to Rs. 20. Thus there is net saving of Rs. 8.12 per acre (Verma and Bhardwaj, 1957). In U.S.A. the weed control in crop has been extensively taken up by chemicals as the cost of manual weeding is high. While a number of manual weedings or intercultural operations are required, only one spraying at the proper stage suffices to control the weeds. An experiment conducted on sugar cane gave the following results :—

Table 13

Relative Economics of Weed Control in Sugarcane

Treatment	Yield per acre mds.	Percentage increase over control	Net profit over control Rs.	Remarks
1. Control (no weeding)	718.3	...	...	Price of stripped comes to Rs. 1.42 per md. Sodium salt 2, 4-D (80% a.e.) at Rs. 3.06 per lb. Each hoeing at Rs. 7.12 per acre. Cost of spraying Rs. 4.00 per acre.
2. 2, 4-D at 4 lbs or more per acre (2 lbs as pre-emergence and 2 lbs as post-emergence)	947.2	31.9	309.75	
3. Hoeings alone	1,048.9	46.0	433.84	
4. 2, 4-D as in treatment 2+hoeings.	1,180.5	64.3	623.72	

A combination of spraying with 2, 4-D and hoeing of the crop increased the yield by 64.3 per cent. Hoeing alone increased the yield by 46 per cent. This was about 14 per cent more effective than spraying of 2, 4-D at the rate of 4 lbs per acre. It was very profitable to apply the weedicide alone or in combination with hoeing. Thus use of chemical weedicides has to be stepped up in this country. In the U.S.A. roughly about 5 million pounds of chemical weedicides are used to control weeds in various crops. The area under crops in India is more than that in U.S.A. Ultimately a much bigger industry for production of weedicides is to be established than in the latter country.

4. *Pest and disease control :* Modern farming without pest and disease control is virtually impossible. In U.S.A. pest control industry is worth more than $ 600 million a year. Every family spends more than $ 10 on use of pesticides. This industry has developed over the past 50 years into a well organised industry. They have developed a number of pesticides to control insects in crops. A large number of pest control companies are operating to push forward the use of pesticides. Every year the sale of pesticides is rising at the rate of 10 per cent. The organisational set up for pest control in U.S.A. is given in Table 14.

These organisations also operate in the agricultural pest control in the same proportion. It has been estimated that the cost of pesticides ranges from 5 to 10 per cent. The major cost is the charge of application of the pesticide in the operational field.

In India it is estimated that about 15% loss of crop can be attributed to pests and diseases of crops. In terms of money value this accounts for a loss of Rs. 450 crores annually. This can be checked largely by intensifying the pest control operations on an increasing scale. In all the states, Plant Protection Services are now working but the advance in pest and disease control is very meagre. These services have reduced crop losses by not more than 1 per cent so far.

Table 14

Percentage of pest control organistions in various kinds of urban/industrial agricultural pest control work

Particulars	*Percentage*
General Pest Control	97
Termite Control	86
Rodent Control	72
Outdoor Pest Control	46
Sale of retail products	46
Fumigation	31
Bird control	31

In the disease control sphere valuable work has been carried out by breeding disease resistant varieties of crops, which are being introduced in different states. The diseases, thus effectively checked in a large measure, are cereal rusts and smuts. Rusts of wheat which caused an annual loss of Rs. 60 crores worth of grain have been brought under check by introduction of rust resistant wheats. The distribution programme is still slow. Similarly *Helminthosporium* resistant strains of paddy have been evolved and introduced. In spite of these advances the check on several of the diseases is still very limited.

A. INDUSTRIAL

Infra- Structure for Agriculture

The prosperity and high rate of production in Japan and U.S.A. are largely due to organization of infra-structure which has been built during the past half century.

1. FERTILIZERS

Soil fertility is the key to increased agricultural production. The other growth factors such as irrigation supply, water and soil conservation, weed, pest and disease control, introduction of improved varieties, cultural practices, soil management are all ancillary to it. A poor soil responds much less to all these measures than a rich soil. In consequence the production of fertilizers should be given very high priority.

In India in the initial stages there was very strong opposition from orthodox quarters to stepping up production of fertilizers in the country. In fact Agricultural Departments in the States were reluctant to push ahead, fast enough, the use of fertilizers. The demonstrations on fertilizers made available free of cost by U. S. A. under T. C. M. Aid Programme given in the cultivators' fields, automatically stepped up their use. The programme of fertilizer production has been slowed down by introducing green manuring programme. The target fixed for it for the Third Five Year Plan is 46 million acres. Besides, being unachievable, it hampers the tempo of fertilizer production and enriching the soil. Since the cost of imported fertilizers is high the indigenous production of fertilizers should be rapidly stepped up. The target of 1.04 million tonnes of nitrogen, and 0.45 million tonnes of P_2O_5 during the Third Five Year Plan period is not likely to be achieved. In the beginning of 1961 the Fertilizer Corporation of India Ltd. was set up with an authorised capital of Rs. 75 crores integrating the fertilizer units in the public sector and bringing them under a unified control, with a view to securing coordination in policy and ensuring efficient and economic expansion and working of fertilizer factories in the public sector. This is bound to build up a vital industry for agricultural development. The original target of 1.75 million tonnes of nitrogen, 0.75 million tonnes of P_20_5 and 0.20 million tonnes of K_20 by the Ministry of Food and Agriculture was highly commended by the Ford Foundation's Agricultural Production Team which had stated, "Procurement of fertilizers and means of producing high analysis fertilizers be given a top priority, including foreign exchange as necessary." The production programme was considerably scaled down by the Industry Ministry. From long range point of view it is essential to step up fertilizer production. Some of the fertilizer projects should be advanced so that maximum benefit can be availed in the Fourth Five Year Plan.

2. AGRICULTURAL MACHINERY AND TRACTORS

In some States there has been a large scale progress in the manufacture of implements and machines for performing agricultural operations. These States are Punjab, Maharashtra, Gujarat, and Madras. In other States the progress has been slow. Till recently the material released for the production of implements and tools has been limited which has handicapped expansion programme for their manufacture. With the decontrol of steel and iron this handicap has been overcome. The country has been importing garden as well as field tractors and power driven machines from foreign countries.

Several firms have been licensed for production but the output so far is very small. The mechanization of agriculture, in consequence, has been very slow. This handicaps production of crops particularly in places where extensive areas have to be covered in a very short period for cultivation of soil, sowing of crops and their harvest. It has been already shown that economy of scale is possible when farm operations are mechanised. The expansion of facilities for the manufacture of agricultural machinery including tractors and their implements, power dusters and sprayers, mechanical reapers and so on should be given high priority. Already the programme for manufacturing 40,000 to 50,000 tractors per annum is being planned. This is a step in the right direction which can go a long way in raising production of crops.

3. Selected Herbicides and Plant Growth Regulators

The results have been summarised to show that the cost of weeding in the crops can be substantially reduced by producing and introducing selective herbicides on a large scale. All the herbicides at present are imported from foreign countries. The cost of imported materials is very high. The formulations available are few and cater for special needs in those sectors of agriculture where improved practices are employed. To popularise their use on a large scale, the industry to organise their manufacture within the country should be set up.

Several plant growth regulators are available for reducing fruit drop in various orchard crops, hastening the sprouting of cuttings and increasing the rate of growth of seedlings in the field. They are used to a very limited extent. Their use can become widespread provided these are indigenously manufactured. A side industry to manufacture these compounds would help in raising production in the country.

4. Pesticides

At present D.D.T. is manufactured within the country and meets a large part of the requirements of the country and further expansion has been planned. The manufacture of other pesticides is being carried on a very limited scale. The pest problem being very serious in the country, the use of pesticides cannot be encouraged unless their manufacture is taken up on commercial scale, as the demand will not be built up on a large scale. The conciousness to control the pests has just now started to be manifest. The industry, once established, can promote their application for controlling various pests in the field in a very organised manner. The industry shall cater to the requirements of insecticides, rodenticides and pesticides which will control pests other than insects and rodents.

5. Fungicides

Most of the fungicides are still imported. A few manufactured in the country hardly meet the requirements for controlling plant diseases of vegetable and orchard crops. The demand for fungicides is fast increasing for seed treatment, for control of airborne diseases and for controlling other endemic diseases of crops. The losses caused by diseases of crop can be reduced substantially by building up a large scale supply of fungicides, by demonstrating their value and by equitable and widespread distribution in all parts of the country.

The fungicide industry can take it up on a regulated basis. In U.S.A. this has been entirely developed by private companies, the operations of which are very well regulated by the governmental agencies.

B. ORGANISATIONAL

1. Farm Planning

In Japan, the demonstration and extension programme is conducted very intensively. The place of Village Level Worker in India is there occupied by graduates in agriculture, animal husbandry and veterinary science and other specialists of this status of education. The Community Development programme was intended to initiate active participation in agricultural development. The Village Level Worker's 80 per cent of the energy was to be devoted to this. The Agricultural Production Team of the Ford Foundation particularly emphasised this aspect and recommended the idea of package programme consisting of intensive education of farmers in better farming techniques through demonstrations, adequate and timely credit facilities to enable farmers to purchase supplies ; strengthening transport arrangements to ensure the mobility of staff and supplies ; adequate and timely supplies for production such as seeds, fertilizers, implements and pesticides through cooperatives ; marketing arrangements and other related services through the cooperatives so that farmers can get the fullest value from their surplus produce and increasing the number of godowns from one to ten per block and organising workshop facilities for repair of implements and machines. With the aid of expert staff "farm production plans" family wise should be developed through the Village Level Worker with a view to combining best improved practices and new crops for increased production and income. A farm management specialist would work in a group of not more than 5 villages. These farm plans would be executed and their results evaluated (Johnson *et al*, 1959).

The package programme was initially introduced in West Godavari (Andhra Pradesh), Shahabad (Bihar), Ludhiana (Punjab), Aligarh (Uttar Pradesh), Pali (Rajasthan), Raipur (Madhya Pradesh) and Tanjore (Madras). The experience gained in these districts has shown distinct improvement in production of all crops. The programme is now being expanded to 80 districts of the country where either the rainfall is adequate or the irrigation facilities exist to increase the production of food grains and Commercial Crops. This is bound to stabilize agriculture on sound lines.

2. Reinvestment of Surplus Income

The present rate of capital investment in agriculture is very low. It hardly exceeds 5 per cent. It must be stepped up to 20 per cent. The productivity of the capital in agriculture, as in other sectors of economy, depends upon capital output ratio. In the first plan the incremental output ratio worked out at 1.88 : 1. For the Second Plan it was approximately 2.3 : 1. In the Third Plan it is envisaged that this ratio would be 3.36 : 1. This represents the take-off stage. In industrially advanced countries this is about 4 : 1. The gross capital formation in India is about 11 per cent (Anonymous, 1956). It should reach a figure of 25 per cent so that in agriculture the investment could be of the order of 20 per cent. At present it is the large and medium scale farmers who reinvest part of their net income. The bulk of the small farmers are not reinvesting their net savings in agriculture. The process has started but it requires reorientation in policies which would hasten the process. This high rate of reinvestment of net income is most important to stabilize agriculture.

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