8.0.1 To operate effectively a library must identify publications in subject literatures which are of high quality to its clientele and must acquire and organize these publications in such a way as to optimize their usefulness. In recent years, however, certain information scientific techniques have been developed for the formal analysis of literatures. In the present work the methods of quantitative growth measurements of literature as well as the techniques of citation analysis have been applied to investigate the trend of growth of journal literature in the field of botany in India from 1930 to 1980 and also to find out the various methods and patterns of citation practices of its contributors with a view to find out 1) self-citation rates, 2) nature of research material used in their researches, 3) language of the citational material, 4) core journal in the field, 5) age distribution of citational materials and 6) subject coverage of the citational materials.

8.0.2 It can be emphasized here that, the botanical research in India as seen through the increased number of publication of research papers and journals, increased specialization in smaller and smaller subject matter areas, interdisciplinary and multidisciplinary team research and increased research grants and manpower developed vigorously after its independence (i.e. 1947). And therefore, the
present investigation which considered the literature from 1950 to the present day becomes most appropriate for studying the nature of botanical research in India.

8.0.3 The review of literature showed that no subject has been subjected to all aspects of citational analysis with a national biasness as is done here. This has two great implications. It not only helps the librarians or the information scientists to assess the amount of national biasness involved in the scientific literature (which otherwise should be of universal in outlook) but also helps them to control organize and manage the information contained in it in the most effective manner within their own country.

8.0.4 With the prevalent idea that the nature of source material has considerable influence on the results of citational analysis (Line, 1979) and with great variations in the choice of materials for the purpose by different workers, the selection of 10 different journals studied for 5 years in average (total 46 years of literature) representing different subdisciplines of botany has been found to be most suitable for a consistent citation study. Applications of relative growth rate methods which had been applied earlier in botany and the Gompertz modified exponential growth curve which had been applied earlier in economics and population studies are new to the field of library and information science. It is hoped that more and more applications
of such ideas would help to solve number of problems faced by information scientists during the present days of information explosion.

8.1 Growth of literature in botany

8.1.1 Price (1956, 1965) has predicted that the annual growth rate of scientific journal literature is about 7%. This prediction would prove real only if the trend of growth of literature would follow an exponential path. But such exponential growth with a constant percentage of increase by year could not be seen from the present data. Similar deviations from a clear exponential growth was also reported by Anthony et al. (1969). Rather the present data fitted accurately to the study of relative growth rates (RGR) which were done for the study of growth rates of individual plants (Blackman, 1919; Hunt, 1978). The RGR gradually decreased from '50 to '80. This indicated that the growth of botanical literature increased with a declining rate from '50 to '80 in India. Consequently the doubling time (Dt) in botanical literature increased from 6.30 years in '60s to 10.02 years in '70s. The increase in the average Dt(a) from '60s to '70s was not as much pronounced as that of Dt(p) which almost doubled in years. Therefore, at the present moment the doubling time of botanical literature in India can be taken as 10 years in average. And if the rate of growth of botanical literature
continues in the rate it grew from '50 to '80, it can be predicted that by 1990 its doubling time would increase to somewhere in between 15 to 20 years. Though the RGR decreased gradually, the average annual growth rates calculated in this case was in between 8.74% to about 9%. This is slightly more than what Price had predicted earlier. However, it should be emphasized here that the overall annual growth rates and the doubling times would not reveal the correct picture since the growth rates over time in scientific literature are not uniform. Therefore RGR and the Dt calculated over the RGR were considered to be most suitable and adopted here.

8.1.2 As the RGR decreased with time, the modified exponential growth curve (Gompertz curve) tended towards a saturation point i.e. the k-value. The k-value for botany as a whole was 1391 articles, but up to 1980 the modified exponential curve had reached only 816 articles which means that by 1990 it would reach the saturation point (as can be seen in a semi-log graph). Apart from tending towards exponential, the year to year actual growth points from '51 to '80 of botanical literature showed some fluctuation at the later years of the observation period i.e. from '70 to '80. The fluctuations from '60 to '70 was not as much visible as that from '70 to '80. The modified exponential curve, however, did not have a quick rise, rather it rose
gradually from '50 to '80 and headed to its probable saturation point sometime around 1990.

8.1.3 The subdisciplines of botany showed great variation in their growth trends. However all of them tended to be exponential heading towards a k-value. This was also evidenced from their gradual declination of RGR values and increase of Dt. The annual growth rates varied from 7.35% to 15.32% and the corresponding Dt calculated over this annual growth rates varied from 9.52 years to 4.31 years. The $1 - 2\bar{R} (aa^{-1} year^{-1})$ decreased gradually from '60 to '80 in pathology and cytogenetics; decreased gradually from '60 to '75 and again increased in '80 in physiology, taxonomy, ecology, embryology and morphology and showed no consistent trend in palaeobotany. The difference between the maximum attainment of the modified exponential curves at '80 for each subdisciplines and their corresponding k-values allowed us to predict that palaeobotany and embryology have already ceased their growth; taxonomy, morphology, cytogenetics would go for another 5 more years; ecology another decade; physiology 2 decades and pathology still has a very long future. Of course, the predictions are liable to be unreliable since the growth rates in the subdisciplines may not follow the same path in future as they have followed in past. But if they do so, then the days of Indian botanical research, except pathology, will be counted!
8.2 Self-citation rates

8.2.1 Self-citing is a common and fundamental attribute of scientific literature and basically its function is similar to other forms of citing. Self-citations in scientific literature make them authentic since the scientists link the arguments with their past and present works which makes their contributions authentic and scientific. However, if one considers the wide range of number of self-citations appearing in different articles, one may wonder about the reason which induces some authors to cite several of their previous publications, while other authors limit their self-citations to one or two. If one considers the value of scientific work and estimates the impact of a body of published literature on other scientific literature through the method of citational analysis, then the rate of self-citations have great practical implications. Self-citation rates in scientific literature may vary between 10% to 20% depending on the field and the stage of development. In botany it was found to be 11.68%. The different subdisciplines of botany ranged from 8.95% to 14.95% with an average of 11.34 ± 2.33% of self-citations. The percentage analysis of the different categories of self-citations revealed that the J/J category was more popular in botanical literature contributing to almost half (46.04%) of the total. The lowest percentage was for the single authors citing their joint
publications. However, the proportions of joint authored and single authored self-citations to their respective joint authored and single authored articles remained more or less equal which makes the popularity of a specific category of self-citations doubtful. The $\chi^2$ values did not suggest any consistent trend either between the authorship of the articles and the self-citations or self-cited authors and their self-citations, except the tendency for articles with joint self-citations to occur more often in the discipline. Therefore the amount of self-citation is not related to the number of authors of a particular article.

8.2.2 57.22% of articles for botany and in average 61.01 $\pm$ 13.33% of articles for different subdisciplines were found to be self-cited in nature. Periodwise analysis of the distribution of self-cited articles showed that, whereas the interest of the single authors remained constant through the decades, that of the joint authors increased to a great amount in their self-citation practices. Analysis of periodwise distribution of self-citations indicated that authors citing their own publications written single-handedly became less frequent through the periods whereas their publications written jointly with others occurred more frequently. This might be due to the present trend in collaborative research in science. But, then, increase of J/S self-citations from '50 to '75 may be explained as to the
authors' preference of citing their own single works even if they were engaged in collaborative research. As indicated elsewhere, the rise of percentages of self-citations through the decades might be attributed to the maturity of the discipline.

8.2.3 50% of self citations in the whole discipline occurred within 3 to 4 years of their actual publications, this made the age of self-citations much lower than the actual age of the literature. It was because the self-citations referred to a more recent group of publications than the other citations did. It might be either due to a relatively young population of scientists and/or due to the high degree of continuity in the work of individual scientists.

Age distribution of specific categories of self-citations showed that whereas authors belonging to pure categories (i.e. S/S, J/J) were relatively younger than the authors belonging to mixed categories (i.e. S/J, J/S) which indicated that, when in collaboration they cited their single publications, one of the authors whose papers had been cited might be senior to the other. This senior-junior relationship is of course a common phenomenon in scientific research.

Decadewise analysis of the percentages of self-citations showed that the self-citations in '50 were much older than those of '60 and '70, but again in '80 they tended to be older. This might be explained in the terms that an increasing number of young scientists might have come into the field during the periods of '60 and '70 which made the age
of self-citations comparatively younger. The high proportion of self-citations in a particular discipline might contribute to a large proportion of recent citations than in the disciplines where the self-citation rate is lower. Therefore, while making a citational study the proportion of self-citations in a particular discipline must have to be ascertained first for achieving an unbiased result.

8.3 Nature of research materials

8.3.1 Analyses of the form of citational materials reveal the nature of research materials used by the authors at the time of writing their articles. The prominence of authors' maximum dependency on a particular or more than one form of research material would not only indicate authors' preference for a particular type of document, it would also reveal the general trend and characteristics of research literature and would help in the organization of research materials in a library or in an information centre.

8.3.2 Authors of botanical articles in India from '50 to '80 depended on a total of 31 individual type of research materials for their professional writings of which 9 individual types namely journals, books, proceedings, theses/dissertations, monographs, reports, annual reports, government publications and professional papers were sufficient to cover upto 95.35% of the total citations. Only journals and books were enough to cover upto 90% of the total. Journals
alone contributed 75% of the total citations and became the most prominent research materials in botanical research. This high amount of journal type citations in sciences was also reported by other authors. Analysis of journal citations by individual subdisciplines, however, confirmed the composition of botany as a 'hard science'—phytomorphology, plant physiology, phytopathology, cytogenetics and palaeobotany falling within expected level while ecology and taxonomy came less than expectations. Time did not seem to have any influence in the use of journals as the main sources of information. 75% of citations belonged to journal type in botany from '50 to '80. However, the decadewise percentages of journal type citations from the total indicated an increasing trend in the use of journal citations. At '80 it almost became 3 times of what it was at '50. Therefore, we may conclude that journal citation usage gradually increased in botany from '50 to '80.

8.3.3 Books formed the next prominent research materials upon which the authors of botany depended for their writings. Book citations contributed only 16% of the total citations which confirmed the general trend in the low percentages of book citations in sciences. Analysis of book citations by individual subdisciplines, however, did not confirm to the expected percentages, they varied to a great extent among themselves. The ranking order of the subdisciplines according to the use of book citations, from low to high, might be
considered as: plant physiology, phytopathology, cytogenetics, palaeobotany, phytomorphology, ecology and taxonomy. Unlike journal citations, book citations showed fluctuations in their percentages through different decades. The decade-wise percentages of book citations from the total type, however, showed an increasing trend in their use. Like journal citations, at '80 it almost became 3 times of what it was at '50.

8.3.4 Among the less prominent research materials, conference proceedings ranked first with 3.38% of total citations. This was followed by theses/dissertations (1.84%), monographs (1.06%). All other types of research materials contributed less than 1% of the total citations.

8.4 Language of the cited materials

22 different languages (other than English) contributed to the cited materials in botanical literature of Indian journals from '50 to '80, out of which the first seven major languages were: German, French, Italian, Russian, Danish, Japanese and Chinese. The overall dominance of English language citations 90.97% over the foreign language citations (9.02%) confirmed the earlier findings of language analysis studies. Of the seven major foreign languages, German was most popular contributing 58.58% of the total foreign language citations followed by French (30.42%) and Italian (4.77%). The popularity of the three
above mentioned foreign languages could also be seen from the fact that they represented in all the subdisciplines, but the relationship of German language with French and Italian was positively significant, whereas French and Italian languages more or less occurred independently. German was also most popular among the subdisciplines $(X = 63.69 \pm 14.87\%)$ except in ecology where French was most popular $(48.68\%)$. Decadewise language distribution in the citations of botany from '50 to '80 showed that as the decades progressed botanists depended less on the foreign language materials.

8.5 Frequently cited 'Core' journals

8.5.1 Journal ranking aids to journal selection by libraries. An ability to rank journals in order of importance, over a given period of time, might seem a valuable method of providing confirmation to libraries on the relative needs to purchase different journals. A list of 40 titles of journals devoted to botanical research have been provided as the most frequently cited journals in the field by Indian workers.

8.5.2 Apart from the 'Bradford's multiplier' the data obtained in this project for the various subdisciplines more or less obeyed the Bradford's Law of Scattering.
8.5.3  The average self-citation rates in the individual journals dealing with various subdisciplines was 10.47 ± 5.76% which ranged from 2.88% in ecology to 20.38% in palaeobotany. The average self-citation rate in botany increased through the decades except in '75, where it decreased considerably. The decadelwise average was found to be 10.03 ± 3.46%.

8.6  Age of literature

8.6.1  A measure of the 'Obsolescence' rate of literature, which can be assessed by citation analysis, can give an indication of how far a search must go back to obtain a representative sample of the published literature in a given field. 25% of journal citations were 5 years old and 50% were 10 years old. The citations to book materials were, naturally, older to journal materials. Slightly <20 years were needed to cover 50% of book citations. The percentages in different age groups decreased gradually with age suggesting that as the age of the cited material increased its relative use decreased. The 50% coverage of botanical serial literature by 10 years, somehow, was similar to its 'half-life' reported by other workers. Comparative analysis of the years required to cover 50% of journal citations in different subdisciplines showed that morphology, pathology, genetics (NCLS), taxonomy, ecology and botany in general (JIBS) required more than 10 years whereas physiology, genetics (IJGP) and palaeobotany required 10 or less than 10
years, and all the subdisciplines except physiology required more than 10 years to cover 50% of book citations, of which taxonomy required more than 30 years to cover that amount.

8.6.2 The maximum percentage of journal citations in botany was achieved by 0-5 age group in all the decades except in '80 where it was 6-10 age group, indicating that towards the recent years botanists used older literature. 50% of citations were covered by more than 15 years in '50, more than 10 years in '60, less than 10 years in '70 and more than 10 years in '75 and '80. But the decadewise maximum percentage of book citations did not show any such trend as journal citations.

8.7 Subject coverage of citational materials

8.7.1 It can be presumed that the amount of dispersion or scatter shown by the citations appended to papers can be related to the breadth of the subject material covered by the authors in the course of their researches. Botany has shown rather a wider subject breadth in comparision to other disciplines. 42 out of 93 different citational subjects covered 99.25% of the total citations in botany. Of the 42 subjects (which also included the subdisciplines of botany), 3 subjects such as physiology (19.13%), genetics (17.11%) and taxonomy (13.27%) were sufficient to cover 50% of the total citations. The main subdisciplines along with the
methodologies together covered 90% of the total citations. The APUPA pattern can be derived from the rank order of the subjects as 13 subjects forming the 'Umbral' region, 29 subjects forming the 'penumbral' region and the rest 51 subjects forming the 'peripheral' or 'alien' region. Agriculture formed the 1st penumbral subject in the ranking order indicating that the authors of botany while writing their articles rather depended heavily on agricultural material than on other subjects. The subdisciplines of botany have shown a much wider variation in their subject breadths. When the subdisciplines were arranged according to their relative subject breadth, they occurred in the following order: genetics biased to cellular aspects, physiology, palaeobotany, taxonomy (JBNH), pathology, taxonomy (BBSI), morphology, ecology, and genetics biased to plant breeding.

8.7.2 It has been found that the main subdisciplines in botany along with some of the fringe subjects like methodologies and agriculture were continuously cited from '50 to '80 but with different rank positions. In '50, morphology and embryology topped the list; in '60 taxonomy and genetics; in '70 physiology and genetics which continued upto '80. The trend from '50 to '80 indicated that the botanical research has shifted from more or less its descriptive nature to experimental nature. The relative periodwic
subject breadth in botany also showed a marked variation from decade to decade. The subject scatter increased from '50 to '75 and then decreased in '80.

8.7.3 The intercitation of subjects would indicate their interdependence on one another to some extent. However, the average values of interdependence of subjects on each other in botany showed a very high standard deviation. The self-dependence or the self-citation values of the subdisciplines ranged from 29.71% to 80.04% with an average of 62.04 ± 17.30%. Similarly the self-derivation values of the subdisciplines ranged from 33.30% to 92.48% with an average of 62.86±19.20%. A study of subject associations within 10 important subjects (selected basing on their rank positions) showed that they gave rise to 45 combinations, out of which 14 (31.11%) associations were positively significant which included 8 subjects such as physiology, taxonomy, palaeobotany, anatomy, morphology, embryology, economic botany and ecology. Two subjects such as pathology and genetics showed complete negative relationship with other subjects. Physiology showed negative relationship with taxonomy and palaeobotany. The negative associations amounted to 11 (24.44%) combinations and the rest of the associations (44.44%) were independent to each other.