INTRODUCTION

Seed is an important basic agricultural input, which has a conspicuous impact on the crop productivity. The shortage of quality seeds of the promising cultivars is a matter of great concern in bridging the gap between the demand and supply of fodder, feeds and grazing resources in India. The availability of the improved seeds of range forage species in particular is very limited in the country and could not back up the national priority and targets of greening more than 70 M ha of land (Singh and Sinha, 1988).

A modes requirement of quality seed calculated on the basis of 10 per cent seed replacement rate for fodder area of 6.9 M ha and annual development of one million ha of wastelands a totals of one lakh thousand tones of cultivated fodder seeds, 25 thousand tones of range grasses and legumes seeds and 500 tones of tree seeds per annum are required. Against this, the availability is only to the extent of 20%, 15% and 10%, respectively in these crops (Singh, 1987). Based on the area of different forage crops in cultivation and the replacement rate, the breeder and certified seed needs for the country has been worked out (Hazra, 1989) which indicated a need of 130.8 tonnes of breeder seed and 1.06 lakh tonnes of certified seed. Multiplication ratio from seed to
seed is also another important aspect, which need to be known pre-hand for organizing the seed production chain.

The productivity and availability of forage seed is important because the crops have been bred substantially for vegetative purpose and as such they are often less seed producer. The pasture grasses, in general are shy seed producers and their production, collection and processing are more problematic than the cultivated forage crops. It has also been established by now that maximization of seed yields from these crops would necessarily be not the same area from where these crops are primarily grown for forage purpose. This indicated possible revenue of research for looking for alternate sites for production of seeds than the traditional areas of growing these crops. The potential demand for range grass and legume seeds arising from wasteland development is related to the strategies adopted for their rehabilitation, other to allow grass cover to regenerate naturally, or to replace the areas with improved materials.

Propagation of improved fodder production technologies especially the improved varieties have not reached to the farmers mainly because of the non-availability of good quality seeds. The productivity and availability of seeds are vital because the crops have been bred for vegetative purposes and as such they are shy seeders with very low seed productivity. Other important factors are that the crops are not often allowed to come to maturity as cutting is practiced for fodder at the vegetative stage. The acute shortage of grass seed and a high cost of nitrogenous fertilizers poses a great problem of forage production in the country. Further the advantage of mixed culture have been realized to be a superiority on the yield over that of monoculture (Frey and Maldonado, 1967 and Donald, 1963) and they further reported that yield and quality advantage have been firmly established for legume grass mixed grown forage.

A concerted effort is required to augment the seed production of cultivated fodder crops for reasonably good production. The problems of organized seed production in range grasses is much more than cultivated fodder’s which required an in depth analysis.

The major problems in forage seed production are: -

Low priority crops
Forage crops are shy seeders
- Harvesting of crops at vegetative stage which do not allow the crops to reach to seed stage for seed production.
- High cost in seed production because of low productivity
- Non synchronous flowering and maturity
- Farmers often do not give required inputs (management and nutrients) for seed crops because of low returns
- Preferential use of low capability land for forages
- No single governmental agency is in charge of development of fodder
- Multiplication ratio is very narrow in most of the fodder crops and is often not remunerative to the producing agency
- No organized seed outlet for marketing and uncertainty of its demand
- Poor extension machinery responsible for the popularization of improved variety

The specific crops may be highly adoptive and most suitable for fodder production in the specific area. However, the crop may not be suitable for higher seed yield in that area. The crops may give higher seed yield in some nontraditional area. For example guinea grass is suitable for humid and sub humid areas but gives higher seed yield in comparatively drier regions.

A large number of physiological parameters also influences the seed yield of fodder crops such as non synchronous maturity of seeds, apical dominance, diurnal variations in seed yield and source-sink relationship (Singh and Hazra, 1995), further, seed productivity of individual crops is significantly affected by the agro climatic zone in which it is produced.

The level of forage seed production is often not encouraging for the reason that the plant breeders generally play much attention on herbage yield while developing variety and the seed production thus become secondary. On the other hand, multicut forage varieties either do not reach the level of seed setting stages or collapse much earlier denying the regeneration after the final cut or they are forced to behave as a poor seed setter. There are ways and means to improve upon the seed production. Although seed is the cheapest and easiest means to establish forage and fodder crops, but the nature of forage seed production is a far more complex phenomena. It is therefore, a
prime concern to develop technology to high quality seed production for the purpose of meeting the demand of seeds and coverage for fodder purpose.

Seed had ability to germinate and complete generation (seed to seed). Seed is declared to be "Quality" when bears minimum standards of physical and genetically purity, viability, germination, seed moisture for storage and seed health. Since it is well known that pasture species in general are low seed yielders which are mainly influenced by the inherent potential of the species/varieties and cultural treatments. In the seed production of pasture grasses and legumes the success depends mainly on the skillful management of the seed crops as several factors damage even in the early establishment phase (Williams, 1984). The climate also plays a major role for the quality seed production of grasses.

By and large the forage crops are shy seed setter, low yielder and need large number of labours for different operations (particularly seed collection and cleaning/grading). Their cultivation and management is quite specialized and location specific. As the result of low yield and more expenditure on different operations the cost/benefit ratio becomes narrow. In the recent advances made in the forage seed multiplication in India, ecologically better and more productive sites for different forage crops have been identified (Singh and Sinha, 1987; Hazra, 1994 b).

Foliar fertilization is gaining importance whenever nutrient uptake throughout the plant root is restricted. The restricted may be either plant or soil limitation. It may be feasible in cases where plants well supplied with nutrients with soil sources reach a stage where a supply through root cannot meet the demand of crops. This phenomenon occurs prominently in legume crops a low efficiency of photosynthate production per unit of N. When plants posses transition phases of flowering the activity of root declined rapidly and acts as barrier to observed nutrient. For example photosynthate appears to be directly used by flower and seed growth. There are two ways to increase the harvestable yield, more efficient use of photosynthate already available to the plant and improving the net photosynthetic input of the plant to fulfill the established but unsatisfied demand. In several crops, there are evidences to suggest that the improvement in yield, from age old to latest cultivars or species is associated with improvement of harvest index, rather than increase in total biomass production (Evans and Dunstone, 1970; Donald and Hamblin, 1976). However, there is no obvious reason
as to why considerable advance should not be achieved, through improved photosynthetic rate at the leaf or canopy level (Evans and Wardlow, 1976). Particularly in the crops where improvement was already occurred in the direction of an increase harvest index, however, as indicated by Gifford (1974), superior photosynthetic rate at the leaf site is not necessarily being reflected in any matter production at crop level.

The key point for achieving high seed yield is to first produce large sink capacity and then to see that this capacity is filled up with translocatory food materials to synthesis good yield of sink material. This can be assessed by photosynthetic efficiency and elemental status of various stages of crop growth, which may be beneficially used, for strengthening the process of source. The forage production mainly depends on the source strength, which is made of leaf area and rate of photosynthesis. Two processes (source-sink) cannot be independent of each other during the course of growth and development. To this end, production factor should be analyses for developing suitable technology for reaping forage seed.

The factors, which control the seed determining, seed components, viz., (i) potential sink formation, (ii) sink strength and (iii) percentage of viable harvested seeds have to be understood fully for their seed productivity. Seed yield component viz., shoot density, number of seed formed per flower, seed weight and percentage of viable harvest recovery are influenced by weather conditions and agricultural practices. It is very difficult to exactly locate the variable determining yield in pasture grasses.

During vegetative growth, sink limitation is not necessarily reflected in low rates of photosynthesis. A higher proportion of carbohydrates can be respires via the alternative pathway in sink tissue. In early stage growth (structural growth) of storage tissue the requirements of amino compounds and mineral nutrients is high compared with the demand of sugars. The surplus of sugar imported via mass flow into storage tissue is than resired as an energy overflow (Lambert, 1982).

Two distinct biological processes operate in growth and development of forage seed plants. The first one leads to terminate into biomass yield and the second originates from the first one and triggers the anthesis, seed development and recovery. The factors, which regulate the seed production, processing, quality and its economics, could be grouped into biological, environmental, operational and organizational. In forage crops, the food material for grain formation is primarily derived from crown root
or stem portion functioning as a reservoir while in cereal crops it is utilized from the lately formed photosynthate in the upper three leaves (Evans et al., 1972). Thus all biological processes and controlling factors which are responsible for the flower initiation, density and the synthesis and utilization of assimilates to seeds as well as its maturity need to be properly maneuvered.

There are several mechanisms controlling photosynthetic functioning. It has been observed that accumulation of certain metabolites may act indirectly or directly on photosynthetic mechanisms viz., stomatal closure and disruption of the chloroplast due to starch accumulation and activity of growth regulators. There is an inverse relationship between photosynthesis and level of carbohydrate above critical limit in leaves. Continuously high carbohydrate level, which is responsible for low photosynthetic rate, is often associated with premature senescence.

The differences in seed yield of cultivars are due to several factors, the prominent being the maturity period, inflorescence density, seed setting and development, test weight and reconciliation with the set of the environmental conditions including the production management. Therefore, the success of any seed production programs lies in the skill of selecting the right cultivars, which could interact favorably with the prevailing or stipulated conditions. Translocation efficiency of food materials plays an important role in controlling the photosynthate formation and the economic yield. Due to high photosynthetic rates in many tropical plants, particularly the subtropical species, the utilization of photosynthates is due to low and inadequate photosynthetic rate, which has close relationship with growth activity.

_Panicum maximum_ Jacq. is native to tropical and subtropical Africa. It is grown throughout tropical and subtropical regions of the world including Uganda, Kenya, Jamaica, West Indies, Trinidad, Brazil, Australia, Malaysia, Ceylon, South East Asia and Philippines. Humphreys (1974) describes _Panicum maximum_ cv. Gatton as variety of medium height, originally from south Rhodesia. O Reilly (1975) described green panic (_P. maximum var. trichoglume_) cv Petric as a native from Africa. The history of introduction into Queensland, Australia is also observed. It is also described as a tall, tufted, summer-growing perennial.

Guinea grass (_Panicum maximum_ Jacq.) is a perennial grass widely grown as forage crop in tropical and warm temperate regions of both hemispheres. _Panicum_
Maximum Jacq commonly known as Ginni ghas in Hindi is a native of tropical Africa and now it is cultivated in other tropical countries. In India it can be easily grown in areas with varied conditions of soil and climate particularly in tropical areas of Tamil Nadu, Kerla, Maharashtra, Andhra Pradesh and also in parts of Madhya Pradesh, Uttar Pradesh, Punjab and Haryana. Further it has good capacity to tolerate against drought, and frost (Shankarnarayan and Dabadghao, 1972).

The Guinea grass (Panicum maximum Jacq.) is well adapted to tropical areas with moderate humid conditions and warm temperature. It can also be grown in eastern states where such conditions prevail during greater part of the year. It is more nutritious and palatable and is also free from oxalates. The grass is leafy, rich in calcium and can be grazed without much damage; it does not become coarse quickly. Its palatability is compares well with jowar and maize. Guinea grass tolerates shade of the trees and comes up well in the mangroves orchards and forest areas.

Panicum maximum is generally recognised as one of the best forage grass of the tropics with good yield potential and produced high quality forage, when properly managed. In vitro dry matter digestibility (IVDMD) of complete culms at the early full head stage range from 41-72% most ecotypes having IVDMD values of more than 60% (Burton et. al., 1973). Crude protein content was found to vary from 4 - 14% of dry matter (Bogdan, 1977; Chauhan, et. al., 1980 and Gupta, et. al., 1980).

In Panicum maximum there are two different adaptive natures of cultivars, one (Panics) is suitable for medium rainfall of subtropics and other (Guineas) in high rainfall of humid tropic. This grass species is a tufted perennial, often with a shortly creeping rhizome variable 60 - 200 cm high, leaf blades upto 35 mm wide tapering to fine point, panicle 12 - 40 cm long, open spikelet 3 - 3.5 mm long, obtuse, mostly purple, glumes unequal, the lower one being one third to one fourth as long as the spikelet, lower floret usual male, upper floret (seed) distinctly transversely wrinkled.

Warm and humid condition with partial cloudiness and light showers of rain favor the rapid growth of this grass. The minimum temperatures should remain above 15 °C but the maximum temperatures beyond 38° C do not favour this grass. As a pasture grasses, it requires a minimum rainfall of about 600-1000 mm and a relative humidity of 70%. It can tolerate rainfall upto 1200-1500 mm. The grass grows well from sea level to an elevation of 2000 meters.
*Panicum maximum* is mainly in the subhabitat under trees (Smith and Rethman, 1989). Through research done in Rhodesia (Zimbabwe), Kennarad and Walker, (1973) and in India Bhatt, *et al.*, (1994) concluded that this association with trees occurs because seedlings of *P. maximum* are better adapted to the under-tree sub habitat. Bosch and Van Wyk (1970) believed that the association was more related to improved soil fertility in the sub habitat. The high N concentration, often found in the soil under leguminous trees, may be the most important factor determining the presence of *P. maximum* in this sub habitat. Donaldson, *et al.*, (1984) and Du Pisani, *et al.*, (1986) showed that the species thrives under conditions of relatively high soil phosphate and nitrogen.

Seed production of tropical pasture grasses such as *Panicum maximum* (Boonman 1971) is beset at difficulties, which are mainly associated with poor synchrony of flowering and with the rapid abscission of the ripe seeds (Humphreys, 1979).

In recent years use of growth regulators have been increasing in agriculture. The aim of growth regulator application is often to influence vegetative and reproductive growth. There by controlling colon length or shoot/root ratio, but it may also be focused on flower or fruit formation. We know that water, CO₂ and mineral nutrients determine the production of plant material. Indeed CO₂ assimilation is the primary process involved in yield formation. It is for this reason that the rate of CO₂ assimilation and factors, which influence is of paramount interest. Photosynthates can be utilized for vegetative growth for the synthesis of storage material and for respiration. The proportion of photosynthates directed towards these three sinks depends on the physiological age of the plant (Warren Wilson, 1969). The net assimilation rate (NAR) is often used to express the rate at which dry matter is occurred and is defined as the net assimilation per unit leaf area.

The processes of growth regulation and differentiation in plants are controlled by endogenous chemicals. Some of which are Indole Acetic Acid (IAA), Gibberellins (GA), Zeatin, Abscisic Acid (ABA), Ascorbic Acid (AA) and ethylene. Plant growth regulators are known to modify the growth and development patterns of plant by exerting profound effect on various physiological processes and hence regulating the productivity (Brenner, 1987; Clifford, *et al.*, 1986; Ptrick, 1988; Setia, *et al.*, 1991).
Growth regulators have very complex role in nodulation and plant growth (Verma and Dubey, 1974; Abbas and Abotabikb, 1976; and Torrey, 1976). The plant growth regulators are expected to play an important role in rectifying the hurdles in manifestations of biological productivity.

Among growth regulators, NAA was found most effective. Foliar application of NAA increased the growth parameters viz., plant height, number of branches/plant, leaf area index, dry wt/plant and plant attributes. All growth hormones applied increases internodes, pedicle length and plant height. Sprayed treatment in general accelerated the growth of plants. The increased seed production was due to increase in number of seed heads/m² and head length. Guinea grass was the tallest, with the highest specific leaf area and biomass.

Foliar spray of nutrients have been found to be beneficial because they are readily absorbed, cheaper to procure and not lost in the root fixation, erosion and leaching (Bould and Hewitt, 1963). Foliar application of nutrients reduces the loss through absorption, leaching and other processes associated with soil application (Vasilis, et. al., 1980). Foliar fertilizations gaining importance whenever nutrients uptake through the plant roots is restricted. The restriction may be either plant or soil limitation. It may be feasible in case where plants well supplied with nutrients from soil source reach a stage where a supply through root cannot meet the demand of crops.

This phenomenon occurs prominently in grass crops. The role of micronutrient is well recognized in crop production in the form of enzymes activator and is required in very small amount. Indian soils are generally deficient in zinc, while other nutrients (Fe, Mn, Cu and Mo) are found in adequate amount but the availability depends upon soil conditions and plant species. Phosphorus induced Zn deficiency is considered the one of the major cause of inadequate zinc nutrition of the crops. Teel (1968) suggested that herbage production increased with high levels of soluble N. In Hungary, Haraszti and Tolgyesi, (1969) found that pasture yields were increased 37, 31, 20 and 17% by Mo, Co, Cu and Mg respectively, when these were applied alone and that yields were further increased by combination with P fertilizer. In composition, the major change was a large increase in Mo concentration with Mo fertilization. In the Russia, similar response in yield from micronutrient fertilization or seed treatment with the micronutrients has been recorded by several workers (Anoshko, 1969; Andreev and
Mikhailichenko, 1970). The majority of Indian soils have an abundance of available potassium and crops mostly do not respond to its application. But forage plants generally use more potassium from the soil than other nutrients except nitrogen. Heavy dressing of potash can cause chlorine toxicity (Skerman, 1977).

Growth of plants basically depends on photosynthesis, respiration and translocation rates of photosynthesis needed during development process of organs. Some of the nutrient (N P K) have been reported to be associated with various physiological process particularly synthesis, accumulation and use of photosynthates, leading to development of new shoots, tiller, proliferation of root and its activity (Miller, 1938). The use of these nutrients is of great importance in regrowth / regeneration of defoliated forage crops.

Foliar application of plant nutrients can be very efficient under certain conditions. Foliar application of N, P and K is therefore, not very common in practice for nitrogen. The most common form of foliar application is urea, which is readily taken up and metabolized in the leaf tissue. According to Franke (1967) urea improves the permeability of the cuticle and thus favours diffusion conditions.

Of the different nutrients N, P, K, Cu, Bo and Zn have specific role in developing potential flower and seed setting mechanism of crop plants. Crop requiring high N failed to produce potential flower and seed set for storage of N during reproductive phase since at the period N is involved in amino acid synthesis a substrate for seed set / flower development. However, this has been found to be correlated with cytokine involved in production of flower morphogenesis (Bruinsma, 1977). There is possibility of enhancement in flower initiation by ammonium involving other compound, eg. polyamine as secondary messenger. Likewise, K and P also seemed to be associated with level of cytokinin in plants during reproductive phase (Horgan and Wareing, 1980; Wakhloo, 1975 a, b).

*Panicum maximum* Jacq. is the major pasture grass species grown for its higher forage production under tropics and subtropics. Although, the systematic information on its agronomical practices, establishment and forage production under different environments is known but its growth, physiology, biomass and seed production as a function of foliar application of growth hormones and nutrients will be helpful to
understand the limiting factors associated with its higher forage and seed yield potential.

Foliar application of growth hormones and nutrients in *P. maximum* aim to produce acceptable yield of high quality seeds at reasonable cost. The development of technologies to improve seed production requires complete information of the trend and factors associated with seed yield. The information obtained through this investigation is recommended as package of practice to enhance the quality seed production in *P. maximum*. The basic knowledge gained by the application and interaction of these chemicals on growth, morphology, physiology and biochemical characters will help in understanding the source-sink relationship and promotion of seed yield in range grasses and the information will be made available to other researchers and users. Such results will open an avenue for successful use of growth regulating substances and nutrients through foliar spray leading to higher vegetative and reproductive yield in range species. This study will also helpful in understanding the morph physiological problems associated with seed yield as well as parameters controlling the seed yielding mechanism, possibilities of increasing seed production potential and the potential of improved management system to increase seed yield in this crop.

Therefore, such investigation have significant value in recommending of growth hormones and nutrients either alone or in combination as foliar spray with suitable doses and time of application for enhancing the quality seed production in *P. maximum*. 