CHAPTER - II

REVIEW OF LITERATURE

The aim of this project is to development and test the field performance of tractor operated stubble shaver-cum-fertilizer applicator for sugarcane crop for various field condition in order to recommend it for use of sugarcane farmer in Gujarat state. The literature which is concerned and related to the present study and previous research work in the field of chosen research problem has been cited in this chapter. The first section of this chapter deals with review of sugarcane planting methods while the second section deal with sugarcane ratoon management while the third section deal with fertilizer application and forth section deal with stubble shaver-cum-off barring operations in sugarcane crop.

2.1 Sugarcane Planting

Bhale (1994) found that the area under ratoons is relatively greater in the tropical states (50% - 55%) than in the sub-tropical states (40% - 45%).

Bakker (1999) recommended that in ratoon cane light tynes should be use. This is valid also for irrigated ratoon cane. Inter-row cropping, although used frequently on farms is not likely to result in an increase in yield. If done at all, it must be carried out sooner after completing the harvest of the preceding crop so that damage to the roots cane would not occur.

Verma and Yadav (1988) noted that ratooning is a planting method for saving seedbed preparatory cost for instance, seed material, planting operations, fertilizer application, and irrigation. It also extends the crushing period of sugar mills, (mature earlier). Several agro techniques (intercropping, polyethylene mulching and trash) were applied to enhance the yield and yield components of ratoon crop.

Chapman et al., (1992) indicated that ratooning ability is one of the important economic considerations in many sugarcanes growing countries to decide the suitability of sugarcane varieties for commercial cultivation. Good ratooning ability of cane cultivars is an essential prerequisite determined by a number of factors. Various plant
characters were associated with ratooning ability of sugarcane varieties and success of the variety depended on its ability to give more profitable ratoons.

Sundara (2008) stated that ratooning of sugarcane is a common practice throughout the world and occupies almost 50 percent of the total area under sugarcane cultivation and contributes 30% to the total cane production in the country.

Yadav et al., (2009) described the demonstration of ratooning as a practice of growing full crop of sugarcane from sprouts of underground stubbles left in the field after harvesting of the previous maiden crop.

Hassan et al., (2010) described the process of production of sugarcane crop which involve many sub-processes, viz., variety selection, planting, irrigation, fertilizer application, crop protection, harvesting, etc. and required decision support at various stages. Considering the complexity of the problems, they have developed decision support tools for various sub-processes.

Above review suggests that sugarcane is a ratoon crop and more than one harvest is practiced in sugarcane crop. Ratooning is a planting method for saving seedbed preparatory cost for instance, seed material, planting operation and fertilizer application.

2.2 Ratoon Sugarcane Management

The experiment was conducted on Ratooning at the Government Seed Farm at Kalai in the Aligarh district in 1939 show that ratoons should be kept only for one year and that they must be manured, irrigated and cultivated in the same way as plant cane. A manured (but not an unmanured) first ratoon is more profitable than a plant cane crop. Manured ratoons provide cane of better quality than plants for crushing early in the season and this extension of the crushing season is a factor of great economic importance to the industry. The cost of manuring first ratoons is sufficiently justified by the increased yield (Anon., 1950).

Sugarcane replication is the cutting of the remains of the sugarcane stump after logging done at the right or lower position of the surface guludan (Koswara 1988). Currently sugar cane preparation is still done the manual uses a fairly simple equipment of a hoe. Problem which arises in relation to manual manipulation is availability.
Kanwar and Kaur (1981) suggested that for getting highest yield from ratoon crop, all the three major nutrients should be applied in a balanced ratio.

Lakshmikantham (1973) at anakapalle (Andhra Pradesh) reported that ratoons are less efficient utilizers of nitrogen as compared to plant canes. Higher dose of nitrogen for ratoons than the corresponding plant crops may be due to depletion of N content in rhizospheric soil. Initially sugarcane ratoons start functioning on old stubbles roots. After 3-6 weeks, old roots cease to function and new roots are developed. Thus, new root system of ratoon crop is surrounded by old decomposing roots of high C:N ratio. Hence, some added dose will stimulate the root decomposition and nitrogen mineralization. Adequate direct application of N is very important for increasing the yield of ratoon crop. Although several studies have been conducted on the effects of nutrient management on plant and ratoon cane, investigations on the additional N application in subsequent ratoon crop has not yet been done to know the growth, yield and quality of first ratoon cane in Bangladesh.

The Growing ratoon crop costs less than plant cane and therefore, achieving high yielding ratoon cane is a valuable objective. This crop is most economical by 25-30 per cent saving in operational cost along with seed material. There is no need for preparatory tillage to grow this crop. Ratoon cane matures earlier than plant cane and thus early supply of cane is assured. As the crop matures earlier, harvesting is easier and field is available for the timely sowing of the next crop (Anon., 2008).

The Ratoon cane contributes about 30% of total sugarcane production in India. Generally, 1 or 2 ratoons are economical. Saves time, establishes & matures early (9 months).
More economical as land preparation & planting operations are not needed (Saves up to 30% cost). Ratooning also saves 1/2 irrigations. Proper ratoon management will increase yield by 7-9 ton/acre (Anon., 2011).

Aamer et. al., (2017) Ratoon crop of sugarcane is considered economical for the farming communities of Pakistan because production cost is 25 to 30% less than plant crop along with saving of seed material.

Champman and Wilson (1996) discussed the economic influence of ratoon for profitability of sugarcane exploitation. It was observed by them that a ratoon can secure the cultivation of sugarcane in State by reducing the costs, motivating sugarcane growers, and more contributions to GDP. Ratoon crop is simple method of cultivation of sugarcane happened after the harvest of cane crop. The buds left over in the underground stubbles develop and give rise to another crop during the season. The first harvest of a crop after planting is called the plant crop i.e. maiden crop and the next yield designated as first ratoon, followed by second ratoon, and so on. It was further opined by them that ratoon was important for sustainability of sugarcane cultivation.

Prasanna and Pattar (2014) reported that the characteristic features of ratoon crop are such that when the shoot portion is harvested the remaining root system being intact will result in fresh tillers from secondary shoots and another crop can be harvested during the following year. In this manner, nearly 2-3 crops can be harvested without much risk and uncertainties. The ratio of the maiden crop and the ratoon crop is 1:3, that is to say only about 25 per cent is maiden crop and bulk of the area is under ratoon crop. Apparently, the ratoon crop deserves much higher attention and care in the present scenario to boost the productivity of sugarcane.

Singh et al., (2012) discussed the trash mulching sustained the improved yield and economic returns of sugarcane ratoon crop. Sugarcane ratoon crop comprise more than 0.50 of India’s sugarcane acreage and reduce the cost of cultivation by 25-30 %.

Sivarman (2009) defined ratooning or stubble cropping as an integral part of sugarcane cultivation practiced in almost all the sugarcane growing countries of the world. Basically, ratoon cropping implies regrowth from basal buds on the stem or crown which is situated at the surface of the ground and harvesting the aerial portion of the plant. Then ratoon developed and gave yield within 12 months.
It was stated that Ratoon saves cost on preparatory tillage and planting material. It gets benefit of residual manure and moisture. Ratoon crop matures earlier and gives more or less same yield as of suru cane (Anon., 2017f).

Thompson (1988) found that ratoon crop produced a leaf canopy much faster than plant-cane and also initially accumulated dry matter at a faster rate.

Pandey et al., (2012) observed that ratooning is an important means of achieving cost effectiveness in sugarcane production. Essentially, ratooning causes saving in cost of production to an extent of 20-30 % in terms of saving seeds, cost of preparatory tillage and planting. No doubt, ratoon matures early with shorter crop cycle with higher recovery during early crushing season that extends milling period. In India, almost around 50 % area is occupied by ratoon crop. Adaptation of any new variety amongst the farmers now depends upon its ratooning potential. Sugarcane is a clonally propagated and long duration crop. Hence, stability in performance in plant as well as ratoon crops is one of the most desirable properties of genotypes to be released as a variety for wide cultivation.

Yadav et al., (2003) reported that ratooning is a common practice in sugarcane cultivation. Ratooning is more profitable as compared to plant crop as land preparation and planting operation are not required. About 50 percent of Sugarcane area is under ratoon crop. For ratoon culture, incorporation of trash is very important. Trash management technology is to be developed in case of manual as well as mechanical harvesting systems for different conditions. In case of mechanical harvesting sugarcane is harvested from the bottom portion. However, precautions should be taken that clump is not uprooted and under cutting is not done. It will affect adversely ratoon crop. In case of manual sugarcane harvesting bottom portion of sugarcane is left in the soil. Cost of mechanical stubble shaving is about 1/3rd as compared to manual practices followed for ratoon cultivation.

Raju et al., (2012) concluded that on the basis of four years of multi-ratooning field experiments indicated that the varieties Co 86032, Co 97008, Co 95020 Co 99004 and Co 2000-10 have been proved as good ratooners in tropical India. Some farmers have illusion that ratoon yield is lower than maiden crop, but the experimental results proved it wrong.
Gravois and Bischoff (2008) stated that ratoon sugarcane is more effective, economic and practically. The plant density is a significant factor responsible for efficient utilization of nutrients. The ratooning operation after harvesting of the maiden crop is very important and significant in ratoon sugarcane field.

Ram et al., (1997) stated that ratoon ability was an important trait in sugarcane varieties hence, selection in ratoon seedlings was warranted, particularly in sub-tropical countries where seedlings remain immature at the time of next season’s planting and hence, may not express their full potential.

Yadav and Shukla (2008) indicated that with small improvement in ratoon, abundant of production add considerably to overall sugarcane production in the country and there are numbers of benefits return to growers such as vacating the fields earlier for sowing of other crops like wheat and other Rabi crops timely, and for mill owner’s by providing mature cane in early crushing period. Thus, the ratoon crop often gives better yield, quality and sugarcane recovery than plant cane crop, if growers followed ratoon management schedule. Excessive tillering in ratoon crop is a desired character but all tillers may not be productive with proper amount of juicing in order to reduce the number of excessive tillers and converting them into mill able cane. Besides, it has added advantages in terms of pruning/cutting of old roots i.e. off-barring, moisture conservation, addition of organic matter, enhanced availability and uptake of plant nutrients, efficient utilization of solar radiation, suppression of weeds, preventing canes from lodging, and good thickness of stalk.

From above review it can be stated that sugarcane is one of the most important crop in India ranked 2nd in area and production among the sugarcane growing country. It is a commercial crop with production of 339.17 million tones and productivity of 68.6 t/ha and varieties Co 86032, Co 97008, Co 99004 and Co 2000-10 have been proved as good sugarcane varieties.

2.3 Fertilizer Application

Vaidya et al., (1978) noted that fertilizer application should be divided in four doses. The first one applied at the time of planting followed by second dose which should be after 6 to 8-week, third dose after 8 to 12 weeks, last one after 20 to 24 weeks. Most of nutrient exhausted during a period of median crop. Thus, ratoon crop required
additional amount of nutrient to be applied with the doses split to three stages. Ratoon cane crop during vegetative stage (Germination and Establishment) required more nitrogen while tillering (formative) stage and grand growth period required more P$_{2O_5}$ and ripening (maturity) stage required K$_{2O}$. This case should be considered for applying fertilizers doses. The first split dose of fertilizer (45 kg. N, 30 Kg. P, 25 Kg. K), corresponding with shaving and off-barring operations of stubble of sugarcane done simultaneously, is recommended; followed by 40 Kg. N, and 25 Kg. k, after 30 days and 60 days respectively, from shaving and off-barring operations.

Jadhav et al., (1997) developed bullock drawn implement for interculturing, earthing up and fertilizer application for sugarcane crop. Fertilizer application system consisted of wooden box of 15 kg of granular fertilizer capacity fitted on a mainframe of the implement. The fertilizer box was provided with two fluted roller type metering bodies for metering fertilizer and two agitators for agitate the fertilizer. The fertilizer was applied at 7 to 8 cm depth and 10 cm away from the plant with 1.5 to 2 ha/day effective field capacity.

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Lal and Singh (2008) showed that cane crops as well as ratoons both are highly exhaustive crop having higher demand for nitrogenous fertilizer because of shallow root system, decaying of old roots, sprouting of stubble buds and immobilization of nitrogen. Ratooning management operations viz. stubble shaving, off-barring, fertilizer application, inter culturing, trashing, etc. are extremely effective for achieving higher yield and quality of sugarcane, reducing the cost of inefficient exploitation of fertilizer. Off-barring is an operation carried out for trimming the old roots of preceding cane crop, reverse the soil so that it has direct influence on aeration, porosity, and permeability of soil.

Dev et al., (2011) concluded that 20 to 25 percent more of nitrogenous fertilizer dose was recommended for ratoon crop, (150 kg N/ha). Nitrogen plays a vital role in all living plant tissues and reduced the number of unwanted tillers and brought into constant number of mill able canes/ha so as to rationalize the amount of fertilizers, and improving the sprout and growth. The aim of modern cane production package is concerned with yield quality, reducing of cost, sustainability of sugarcane cultivation, and environmental impact. Therefore, efficient use of fertilizer N has become more crucial, moreover use of farm generated organic resources such as crop residues, vermi-
compost, farmyard manure and microbial fertilizers are being increasingly used to arrest the decline of soil fertility and to restore the soil physical properties.

Humbert (1979) reported that the high productivity of sugarcane has been obtained from variation in fertilizer placement when applied at 10 to 15 cm depth and at reachable distance to plant root system, covered by slight layer of soil. Result from several experimental conducted in India, indicated that a tonne of sugarcane removes 5, 1.15 and 5.25 kg of N, P\(_2\)O\(_5\) and K\(_2\)O respectively from soil.

Haynes (1985) noted that by using implement for fertilizer broadcasting has significant impact, since N fertilizer incurs high input cost, and has environmental implications due to nitrogen loss. There is pressing need to optimize the supply of N as per the crop’s requirement. It is observed that the efficiency of fertilizer is improved when it is applied by implement to most crops as well as sugarcane.

Zende (2002) described soil fertilizer as a result of many physical, chemical, and biological factors. In fertile soil, the high yielding crop will deplete the soil more rapidly and eventually yield will be decreased, if nutrient supplements are not provided.

Singh and Srivastava (2011) showed the influence of various nutrient supply systems on sugarcane growth, yield and on soil health in sugarcane plant –ratoon system. Out of all five treatments based on various combinations of organics and fertilizer nutrient supply, integrated use of organics and fertilizers up to 75% substitution both ways recorded the highest cane yield (78.5 t ha\(^{-1}\)) for ratoon crops. However, organic carbon and available nitrogen enrichment (0.65% and 243.8 kg ha\(^{-1}\) against 0.40% and 192.4 kg ha\(^{-1}\) initial) were found highest in treatments involving total supply of recommended nitrogen through organics only. Entire quantity of phosphorus, half of nitrogen and potash are applied as the first dose and the remaining as the second dose. The first dose is incorporated into the soil while off-barring operation is carried out, followed by trash mulching, and the second dose is applied around the clump.

It is concluded that from above reviews generally, sugarcane crop has three doses of fertilizer as a vegetative stage, tillering stage and ripening stage. Ratooning of sugarcane having a higher demand of nitrogenous fertilizer. And important management of ratooning crop are stubble shaving, off bearing, fertilizer application and inter culturing.
2.4 Stubble shaver-cum-off barring operations in sugarcane crop

Chancellor (1987) noted that cutting had been given different names in many special cases describing the special kinds of cutting device or cutting procedure, such as chopping, mowing, sawing, splitting, slicing, dicing, chipping, etc. Sugarcane stubble required special cutting device to avoid fraction and containment of cane and moreover for optimum use of energy. Damage of ratoon stalks caused by manual work, mechanical cutting was used as indicators of quality of cutting. The ratoon cutting efficiency was dependent on different factors such as field moisture, trashing before ratoon operations, skill of operator, sharpness, toughness and tilted of blade, forward traveling speed.

Chauhan (1993) carried out a field experiment to study the effect of height of plant on cane harvesting, stubble shaving and earthing up on cane and sugar yield of ratoon crop. It was reported that ground level harvesting of sugarcane (Cv. Co. 1148) significantly increased ratoon yield by 11 % and 15 % when harvested at 5 and 10 cm above the ground level respectively. Stubble shaving of ratoon crop after harvesting of plant cane significantly increased the sugarcane and sugar yield (15 %) than neglected ratoon crop without shaving.

Ahmed and Giridharan (2000) concluded field experiments in 1994-96 in Tamil Nadu studied the crop management of sugarcane ratoon crop. The results revealed that trash removal and stubble shaving increased produced the highest mean cane yield of 117.1 t/ha compared with trash removal but no stubble shaving (97.2 t), trash burning and stubble shaving (95.1 t) and trash burning and no stubble shaving (78.6 t).

Jeyakrishman (2003) developed a ridger weeder attached to low-hp tractor which performed weeding as well as earthing up operation simultaneously. It consisted of main frame, central shank and ridger bottom. The distance between the outer edges of the rear wheels of the mini tractor was 1.2 m and width of implement is 1.0 meter so it could be used in 1.5 m spacing crop of sugarcane without damaging the crop. The depth of earthing up operation was reported to be 20-23 cm. Effective field capacity of the implement was 0.8 ha/h.
Radite and Suastawa (2009) concluded on experimentation objective of this research was to development, fabricate and test a prototype of sugar cane stubble saver based on powered disk mechanism. In this research, a heavy-duty disk plough or disk harrow was used as a rotating knife to cut the sugarcane stubble. Results of field test showed that powered disk mechanism could satisfy cut sugar cans stubble. However, scalloped disk type gave smoother stubble cuts compared to that of plain disk. Plain disk type gave broken stubble cut. Higher rotation (1000 rpm) resulted better cuts as compared to lower rotation (500 rpm) both either on plain disk and scalloped disk. The developed prototype could work below the soil surface at depth of 5 cm to 10 cm. With tilt angle setting 20° and disk angle 45° the width of cut was about 25 cm.

Singh et al., (2010) showed that a number of useful equipment’s for sugarcane crop have been developed and demonstrated on a limited scale at different places. This equipment gives benefits of time, labour and cost saving and would definitely make sugarcane cultivation more profitable besides reducing human drudgery. There is a need for concerted efforts by different organizations including sugar industry, State Agricultural Universities, Research Organizations, for popularization of these equipment. Nowadays, labour scarcity coupled with high labour wage rate has greatly affected sugarcane field operations. With this implement, all the operations in sugarcane field could be carried out in a time. Improved agricultural machinery could increase production and productivity of sugarcane per unit time, area and input at reduced cost of unit operation.

Singh and Srivastava (2011) stated that ratoons play an important role in improving overall economics of sugarcane productions. At IISR Lucknow, a numbers of sugarcane ratoon management devices which executes all the operations involved in management of ratoon crop, have been demonstrated.

Choudhary et al., (2016) suggested that retention of sugarcane trash can play an important role in replenishing soil quality and reducing environmental pollution, but there is a lack of suitable machine for placement of fertilizers. To address this and other issues for low yields of ratoon sugarcane, a prototype of multi-purpose machine was developed for operations like stubble shaving, off-barring, root pruning and drilling of basal fertilizers, and evaluated with ten on-farm trials on black soils varying in texture. The improvement in cane yields averaged 16 and 11 % over the trash burning (farmer’s
practice) and chopping followed by recommended practices of fertilizer application (0.45, 0.45 and 0.10 N as basal, at earthing-up and onset of monsoon rains, respectively). Therefore, the fine-tuning of this prototype should offer a practical and economic solution of trash burning problem in sugarcane cultivation.

Sharma and Singh (1988) developed tractor mounted PTO operated multipurpose equipment for mechanizing sugarcane ratoon culture. The implement could have performed stubble shaving, off-barring, tilling in the interspaces between two rows and fertilizer application simultaneously in one pass. The implement was made of two wooden boxes of 550 x 250 x 300 mm having trapezoidal cross section with sidewalls angle of 30° provided on the auxiliary frame. The fertilizer was agitated and metered through a disc having three holes of 9, 11, 12.5 mm diameter. Desired hole was selected as per the requirement. The drive to the agitator system was given with the help of lugged wheels which had been calibrated for applying nitrogen through urea at the rate of 50, 75, 100 kg N/ha as basal dose. It has output of 3.5 ha to 4 ha/day of 8 working hours.

Sivaraman (2009) defined ‘ratooning’ or ‘stubble cropping’ as an integral part of sugarcane cultivation practiced in almost all the sugarcane growing countries of the world. Basically, ratoon cropping implies regrowth from basal buds on the stem or crown which is situated at the surface of the ground and harvesting the aerial portion of the plant. Then ratoon developed and gave yield within 12 months.

William et al., (2009) described the shaving operation of sugarcane stubble in which the part above ground level should be cut using a very sharp blade which helped the healthy underground buds to sprout and establish a deeper root system. It facilitated optimum utilization of the nutrients and moisture. Off-barring is an operation which consist cutting on either side of ridge using a plough. It would loosen the soil and trim the old roots to develop better root system and thereby better absorption of nutrients and water.

Rajula and Thiagarajan (2011) showed that by use of good management practices, the ratoon yield can be increased. Variety with good rationing potential and good plant crop are the essential prerequisites for good ratoons, concurrent with basic ratooning operations, viz. stubble shaving, off-barring, gap filling, and proper crop management practices, to get higher ratoon yields. The stubbles protruding out of the
field are cut below ground level using a sharp spade to facilitate healthy underground buds to sprout and establish a deeper root system in the ratoon crop. Off barring is an operation wherein the ridges are broken or cut on either side to facilitate quicker development of fresh root systems and helps in vigorous growth of the young crops.

From above review it can be concluded that a significant increase in yield of ratoon crop is observed when harvested 5 cm to 10 cm above the ground level. Stubble shaving can be increased production of sugarcane crop. And the equipment of stubble shaving gives benefit of time, labour and cost, would make sugarcane cultivation more profitable and reduce human drudgery. There is a lake of suitable machine for placement of fertilizer of sugarcane crop cultivation.

**General Considerations from the Review of literature/ Salient features of review:**

Sugarcane is a ratoon crop and more than one harvest are practiced in sugarcane crop. Ratooning is a planting method for saving seedbed preparatory cost for instance, seed material, planting operation and fertilizer application, and it is one of the most important crop in India ranked 2\textsuperscript{nd} in area and production among the sugarcane growing country. It is a commercial crop with production of 339.17 million tones and productivity of 68.6 t/ha and varieties Co 86032, Co 97008, Co 99004 and Co 2000-10 have been proved as a good sugarcane variety and it has three doses of fertilizer as a vegetative stage, tillering stage and ripening stage. Rationing of sugarcane having a higher demand of nitrogenous fertilizer. Important management of ratooning crop includes stubble shaving, off bearing, fertilizer application and inter culturing.

Stubble shaving can increase production of sugarcane crop and the equipment of stubble shaving gives benefit of time, labour and cost, would make sugarcane cultivation more profitable and reduce human drudgery. There is a lake of suitable machine for placement of fertilizer of sugarcane crop cultivation.