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Cultivation Practices of Aloe – A Review

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ABSTRACT

The Aloe is a arid climatic plant of high economic importance. In Africa, Latin America and in various parts of Southern Europe Aloe plants are so very popular. In India it is grown in hot and dry regions. The demand for Aloe plants is increasing among consumers, and, accordingly, production and its cultivation practices are gradually gaining importance due to increase in profit. It contains vitamins, minerals, amino acids, carbohydrate etc that accounts for about 25% of its dry weight which improve the immunity response of the human body. It has also got medicinal and cosmetic properties. This review aims to know the status of knowledge regarding biology, cultivation, and nutritional value of Aloe grown in arid climatic zone.

Key words : *Aloe, Cultivation practices, Nutritional value and arid climatic zone.*

Introduction

*Aloe vera*is derived from the Arabic word "Alloeh" which means "shining bitter substance" and Vera which means "true" (Cristaki *et al.,* 2010; Surjushe *et al.,* 2008). The species was first given by Carl Linnaeus in 1753. It was originated in Africa. In the 17th century it is grown in South Africa and Latin America after then introduced to China, India and various parts of Southern Europe (Cristaki *et al.,* 2010; Crosswhite *et al.,* 1984; Grindlay *et al.,* 1986 and Akinyele *et al.,* 2007).

Aloe vera is a cactus-like plant (Cristaki *et al.,* 2010). The leaves are grey-green to bright green having small white teeth in the margin (Grindlay *et al.,* 1986). It has got medicinal and cosmetic properties (Cristaki *et al.,* 2010; Eshun *et al.,* 2004). 20-30% of the leaf contained aloe juice (Cristaki *et al.,* 2010; Bordreau *et al.,* 2006). There iscolorless, tasteless gel which is the pulp or mucilage (Cristaki *et al.,* 2010; Reynolds *et al.,* 1999). It contains 98.5% water, uronic acid, fructose, hydrolysable sugars and enzymes (Cristaki *et al.,* 2010 and Rowe *et al.,* 2004). The gel comprises of 70-80% by weight of the whole leaf (Bordreau *et al.* 2006). *Aloe Vera* contains vitamins, minerals, enzymes, sugars, phenol compounds, lignin, saponine, sterol as well as amino acids and carbohydrate that accounts for about 25% of its dry weight which improve the immunity response of the human body (Green, 1996).

Cultivation

Climate

It is grown in regions receiving annual rainfall of 35-40cm. It is cultivated in arid regions (Jat, 2015). The mean annual temperatures ranges from 19 to 27 degree Celsius, but can tolerate temperatures from 10 to 35 degree Celsius. The intensity of leaf spot of disease reached its peak (56.67%) during 48th met week, while intensity reduced to 48.18$^{\%}$ during 50th met week. So, minimum temperature and relative humidity exhibit negative and significant correlation with disease of both level of significance (Borekar *et al.,* 2014).

Soil

Sandy loam soils with alkaline pH are preferred (Rajeshwari *et al.,* 2012). Aloe vera can also tolerate saline and sodic soils (Akinyele and Odiyi, 2007; Fern 2014; PROTA, 2017). The plant does not penetrate deep into the soil as it has got shallow root system. However, water logged soil is not unsuitable (Das *et al.,* 2004). The soil physical, chemical and biological propertiesis enhanced by organic carbon present in it (Chowdhury *et al.,* 2018). Soil organic matter have stabilization mechanisms, that isit protects the labile molecules, and enhancement of aggregate stability (Lutzow *et al.,* 2006). Aloe vera can be grown in acid, calcareous, non calcareous, charland having low organic matter content (Chowdhury *et al.,* 2018 and Chowdhury *et al.,* 2020). Under shade, water stressed plants and irrigation with brackish water high aloin was found (Tawfik *et al.,* 2001).

Propagation

About 15 to 18 cm long root suckers or rhizome cuttings of Aloe vera are planted. 15000 pups are required for plantation of one hectare of land (Das *et al.,* 2016). Medium sized root suckers are cut and directly planted in the main field (Rajeswari *et al.,* 2012). Three to four suckers are produced by each mother plant throughout the growing season (Smith and Van Wyk, 2009). *Aloe vera* seeds are fertileand incompatibile (Botes *et al.,* 2009). The percentage of seed germination in vivo condition was observed very low that is 0 -25%. Infection of yellowish brown rotmainly occurs at the base of older or mature leaves (Gantait *et al.,* 2014). Differentiation of non-meristematic tissues produce adventitious shootsknown as axillary shoots (Gantait *et al.,* 2014). To survive as ex-vivo plants many lateral roots were obtained in IAA media (Gupta *et al.,* 2014; Jayakrishna *et al.,* 2011). The main agro-morphological parameters were highest where there are four pair leaves and few were there at one pair leaf (Saran *et al.,* 2019). Auxin is the only that parameter which improved cell division in root apical meristem and subsequently root induction in a media supplemented with 2.0 mg/l Indole Butyric acid and 0.5 mg/ LNapthalene acetic acid (Molsaghi *et al.,* 2014).

Planting time

Planting is done in July - August during monsoon and in November - February under irrigated conditions (Rajeswari *et al.,* 2012). Highest values of (leaf number and leaf weight); (gel); (aloin) that is (11.0, 24.3, and 35.3 plant-1; 2.8, 5.8 and 8.9 kg plant-1; 117.2, 241.3 and 359.8 ton ha-1); (0.9%; 25.4, 52.2 and 77.6 g plant-1; 1054.5, 2171.5 and 3192.4kg ha-1); (0.2% ; 5.9, 12.2 and 18.1 g plant-1; 246.1, 506.7 and 752.8 kg ha-1) during the 2nd season for offsets, mother and whole plant respectively. When the temperature is low reaction processes become slower. Temperature is a such phenomenon that indirectly affect plant morphology, growth, roots turn over etc., if it is not within the maximum and minimum range. Its growth is affected by soil moisture, salinity, availability of nutrient and minerals together with other processes (Mohamed *et al.,* 2017). About 37,000-56,000 suckers are necessaryto plant in one hectare area (Jat *et al.,* 2015).

Method of planting

Plants regenerated by tissue culture techniques were bigger in size and increase in carbohydrate, protein, chlorophyll and phenol contents were seen (Saggoo and Kaur, 2010). Common bean companion planting recorded highest innumber of leaves, total height, length, and width. Companion planting promotes is a promising alternative to aloe cultivation (Robledo *et al.,* 2017).

Manuring

Significant increase in the yield of leaves per ha, maximum net returns, benefit:cost ratio and number of suckers was observed with irrigation at IW/CPE ratio of 0.3 over IW/CPE ratio 0.1 (Bharadwaj, 2011). Maximum shoots per explant, shoot length was observed in medium having 4.0 mg/l BAP, 0.2 mg / l Naphthelic acetic acid and 20.0 mg per l

$AdSO_4$. Again highest root length, root response was seen in medium having 2.0 mg per l IBA and 0.5 mg /l Naphthelic acetic acid. This is due to maximum cell growth and greater nutrient uptake (Das *et al.,* 2017). Application of vermicompost at 5 tonnes per hectare increased available nitrogen and phosphorus content in soil. The increase in available P isdue to release of CO_2 and organic acids during decomposition that solubilizes native soil phosphorus (Marapi, *et al.,* 2015). Combined application of farm yard manure at 10 tonnes per ha and vermicompost at 20 tonnes per ha lead to maximum number of tillers. This is due togreater nutrient availability (Guleria *et al.,* 2013). With application of full dose of fertilizer it showed the highest length of leaves but highest length of the largest leaf was seen when half of phosphatic fertilizers was applied. This results due to maximum cell growth and turgidity (Barandozi *et al.,* 2011). The total nitrogen level in soils were 1.07 g/kg with cultivation of aloe vera under 80 kg N/ha can be recommended as the optimum nitrogen application in sandy loam soils (Babatunde *et al.,* 2008**)**. The average leaf area was increased with applications of urea and DAP. This is due to increased amount of nutrient uptake (Dastagir *et al.,* 2015). Vermicompost had beneficial effects on physical properties of soil, nutrient uptake. It improved the quality and quantity leaves and antioxidant properties (Yavari *et al.,* 2013). Different nitrogen levels significantly affected all of the parameters. The suckers treated with 150 kg nitrogen ha-1 showed tallest plant height, highest amount of gel per leaf, leaf breadth, leaf thickness, leaf volume, maximum no. of leaves and heavier leaf weight. Nitrogen is major component of chlorophyll. The more the nitrogen the higher will be the chlorophyll contents and hence more weight was seen due to more vegetative growth. High rate of photosynthesis results in higher biomass production because of the higher level of nitrogen (Rehman *et al.,* 2016). With application of 50% P and 50% K the plant produced highest agro chemical parameters. Increased the cell division and elongation was observed with application of nutrient matter which provided the better results due to better nutrition (Barandozi *et al.,* 2011). Media having 4.0 mg / l BAP, 0.2 mg/l Naphthelic acetic acid and 20.0 mg/ l AdSO4 gave maximum shoots and highest shoot length. Again with 2.0 mg per l IBA and 0.5 mg per l Naphthelic acetic acid showed longest root length. High cytokinin to low auxin ratio favoured the response of growth of explants during the early stages of explants initiation. The response of explants was found to be detoriated in establishment media with increase in auxin concentration. It might be due to that at early growth stages, shoot tips contain more endogenous level of auxin, thus require less exogenous application of auxin. For multiplication, cytokinin has been utilized because it has the ability to overcome apical dominance of shoot which enhances the branching of lateral buds. In presence of cytokinin, the dormant buds of vegetative apex are stimulated to grow and elongate. The increase in shoot length is the result of rapid elongation of cells which is due to cell division and cell differentiation. Shoot proliferation in tissue culture is largely due to the action of BAP. Aloe plants with 300 kg/ fed calcium super phosphate increased the vegetative growth as phosphorus in calcium super phosphatean essential for cell division, and for development of meristem tissue. Potassium is required for the translocation of carbohydrates from the leaves to the root system (Ahmed *et al.,* 2011). Improvement in barbaloin content in Aloe vera was observed with inoculation of AM fungi. Soluble phosphorus was adsorbed by root hyphae of AM fungi leading to proper growth and barbaloin content (Pandey *et al.,* 2009). Urea an important source of nitrogen and amino acids and is used in biosynthesis of proteins which leads to enhanced growth, leaf gel and chlorophyll contents (Eisa *et al.,* 2017).

Nutrient Content

Nitrogen content was highest in gel as well in juice, when the plant has 4 leaves and when the plant had 9 leaves. Significant difference in gel NO_3 and P concentration between mulch and bare soil treatments was seen. The concentrations were 249 ppm NO_3, 35.4 ppm P, and 514 ppm K (Cruz *et al.,* 2002). Colonization with AM enhances the nutrient uptake and its growth. Efficient use of P resources was seen with inoculation with mycorrhizal fungi (Tawaraya *et al.,* 2007). Higher N and protein content that is 0.95 per cent and 5.93 per cent respectively, were seen from 200 kg N and 200 kg K per ha combinations. Excess application of N and K to the soil have limited the uptake of other essential nutrients by the plant leading to lack of significantly differences (Hossain *et al.,* 2007). Uptake of NPK was maximum in 75 kg N, 3.75 tonnes vermi compost and Azotobacterthat is 83.68 kg per ha, 43.27 kg per ha, 50.08 kg per ha respectively. Higher biomass production may be the

main reason for higher uptake of nutrients. Residual effect of vermicompost improved the metabolic activities inside the plant might which results for better nutrient uptake and higher nutrient availability (Ahmad *et al.*, 2016). Fertilization level significantly affected the N, K, Ca, Mg, Na, Mn, and Zn concentrations in leaf tissue with the higher values recorded with standard fertilization than with the reduced fertilization. The highest concentrations of N, P, K, Mg, Zn, and B were seen in the treatment with no NaCl as compared with plants treated with NaCl that is 20.4 g per kg, 9.5 g per kg, 20.8 g per kg, 4.8 g per kg, 15.9 mg per kg, 16.6 mg per kg and an opposite trend was observed for Na and Cl concentration in leaves (Cardarelli *et al.*, 2013). High N uptake was observed in nutrients without Zn. Phosphorus and calcium uptakes were highest in nutrient without PK and K. The highest Mg uptake was observed with plants in nutrient solution without Cu while those without Mn, NPK, S, P and deionised water had low values. High protein content, was seen when the plant was grown in soil without Ca and K, high fat content was seen when grown without NP and P. High carbohydrate content means that even when grown under similar condition, the variation would be unpredictable based on nutrient available for that plant during the growing period. If carbohydrate content might be reduced if there is nutrient in the soil (Owoade *et al.*, 2016). Highest P concentration and uptake by the leaf were seen with application of 120 kg phosphorus per ha. The P uptake was higher with high doses of P application compared to control. Addition of higher dose inorganic P fertilizer release higher amount of P quickly which enhances P availability to plants compared to low dose of P. The higher P availability at higher level might trigger greater P uptake by A. vera (Sultana *et al.*, 2020). For 80 per cent leaf biomass the K requirement and the critical leaf K concentration were 72.5 kg per ha and 1.29 per cent, respectively (Sultana *et al.*, 2021). Amino acid proline (2.15 µg/g) and chloride (8.27 meq /l) ion increased by severe drought. Decline in water content affected protein synthesis, increase in transpiration through cuticle and irregularities in the protoplasm. The absence of zinc will disturb the metabolism of proteins, disrupts photosynthesis, auxin and expression of gene. The destruction or absence of chlorophyll molecule occurred due to decrease in plant available moisture. Increase in preserved pigment chlorophyll were observed with application of zinc and increase in foliar zinc increased chlorophyll content. The amounts of chloride enhanced when irrigation and drought stress was restricted in Aloe leaves. The accumulation of chlorine was observed due to absorption by the roots and discharge from the leaves to vessel. The measure of chloride can indirectly express the power of tolerance (Shams *et al.*, 2015).

Spacing and Planting

About 28000-34000 Aloe vera suckers are required for planting in one hectare (Rajeswari *et al.*, 2012). The water expense efficiency was high with spacing of 60x45 cm. (Vaishist *et al.*, 2009). When the plants are planted at 60 x 30 cm spacing along with the application of 2.5 tonnes per ha vermicompost it showed higher leaf yield and gross monetary returns. So when the organics are applied itlead to higher cell division and elongation without affecting theuptake of nutrients (Patke *et al.*, 2018). The highest amount of the active substances and maleic acid in Aloe wasseen in treatment of 150 kg/ha having density of 4 plants/m^2 as: 1133/3µg/g aloenin, 429/3 µg/g barbaloin and 312 g/100g maleic acid respectively (Nematian *et al.*, 2011).

Irrigation

Good yield is obtained when Aloe is irrigated immediately after planting and during summer seasonand also when there is no waterlogging (Rajeswari *et al.*, 2012). García *et al.*, 2007 observed that under high water stress conditions reduction in opening of stomata was seen which in turn reduces yield and growth of the plant.Theunique features of CAM plants that is having cells with hydrenchyma helps it to survive in drought environment (Newton, 2004). Irrigation with 40 mm: CPE50 mm= 0.8 and again irrigation with 40 mm: CPE40 mm= 1showed highest values of water use efficiency, aerial biomass and gel production due to greater production of biomass (Silva *et al.*, 2010). In water deficit conditions cell elongation was not observed due toobstruction of flow of water from the xylem to the surrounding elongating cells (Ahmad *et al.*, 2018). The flow rate of sap decreased with water deficit, and increased in synthesis of proline, soluble and total sugars was observed (Herrara *et al.*, 2010). Latex and dry gel yields were seen in plants receiving a combination of less frequent irrigation (every 20 days) and high fertilizer rates (12 g/pot) or frequent irrigation (every 8 days) with no fertilizer application (Yepez *et al.*, 1993). Plant growth and plant biomass was af-

fected with irrigation with saline water because high salt content is detrimental for growth. When the soil water potential is reduced then all the leaf parameters are affected. This is due to production of low amount of leaf biomass (Nema *et al.,* 2009). Aloe vera transpiration rates were notably reduced to zero by day and reached low values by night when the relatively large and low frequency stomata are open resulting in accumulation of CO2 by night and accumulation of malate while by day (Sheteawi *et al.,* 2001).

Intercropping

Leguminous crops can be inter cropped with Aloe vera that improved the soil health and generate additional income (Jat *et al.,* 2015). Aloe intercropped under *Melia composita* at closer spacing (2x 2 m and 2 x3 m) resulted in higher growth, biomass and quality of Aloe vera gel as compared to wider spacing of M. composita and sole cropping of Aloe vera which lead to greater amount of phytochemicals (Jilaria *et al.,* 2017).

Intercultural operations and weeding

Two to three hand weeding should be done within a month after planting to promote growth and suckering of Aloe (Jat *et al.,* 2015). Use of atrazine to control weeds in aloe (PLM, 2015). The germination of seedsof Garden ress, red root amaranth and dandelion is inhibited at 2.5% leaf and flower extract. This is due to presence of allelochemicals like tannins, wax, flavonoids and phenolic acid in Aloe vera (Alipoor *et al.,* 2012).

Harvesting and Yield

Crop is harvested after 18 months of sowing (Rajeswari *et al.,* 2012). The yield is about 12 ton ha^{-1} $year^{-1}$ when Aloe is grown organically (Bhowmik *et al.* 2019; Rajeswari *et al.,* 2012). When the water availability is low the leaf biomass yield is reduced (Rodríguez-García *et al.,* 2007). The yield was 44.5 to 58.5 tonper haper year of density of 10,000 plants per ha (Flores-Hernández *et al.* 2004). When N fertilizer was applied growth and production of Aloe vera was improved (Hazrati *et al.,* 2012, Van Schaik *et al.,* 1997). All the leaf parameters recorded highest in harvesting at three and a half months interval, and minimum values were observed in harvesting at one and a half months interval (Hazarika *et al.,* 2018).

Genotypic and phenotypic coefficients were maximum for dry latex/ aloe plant which is followed by gel yield per plant. The reason is significant correlation of plant spread, fresh weight per leaf and gel yield per leaf with leaf yield per plant (Ahmad *et al.,* 2016). The number of leaves per plant and water use efficiency were highest spacing of 60X45 cm and minimum under 45X45. This is because of higher moisture storage (Bhushan *et al.* 2009).

Ecotype TVM recorded the highest leaf yield per plant of 1597.37 g and gel yield of 1731.60 g with the gel quality parameters that is moisture (99.20%), acidity (3.93), total solids (0.81), soluble solids (0.71), fibre (0.10%) and reducing sugars (1553.70mg l-1). This is due to more leaf and more number of pericyclic cells in the vascular bundles to divert its photosynthates towards the production of more secondary metabolites – the alkaloids (Ganesh *et al.,* 2009). Vermicompost and vermiwash was effectivealong with inorganic source of fertilizer. When the chemical fertilizer doses are high then it results in release greater quantity of nutrients and increased uptake by plants which ultimately leads toincreased growth and yield components of *Aloe vera* (Saha *et al.,* 2005). Inoculation with mycorrhizal fungi helps to acquire P and N from soil (Tawaraya *et al.,* 2007). Increase in leaf parameters were observed with application of 50% cowdung and 50% soil. This is because sole application of urea had a little effect on plant character over cowdung (Hasanuzzaman *et al.,* 2008). Highest fresh leaf weight, fresh gel weight and dry leaf weight at harvest were obtained when it is treated with 25% inorganic fertilizer and 75% poultry manure. This ultimately lead to increase in yield and high Benefit Cost Ratio value (Chowdhury *et al.,* 2020). Effect of N on yield did not agree with results obtained by Yépez *et al.* (1993).

Processing of Aloe Vera

The hand-filleting method was emerged to avoid adulteration of the fillets (Rajeswari *et al.,* 2012). Thegel is also used as flavoring agent (Ahlawat *et al.,* 2011). Aloe vera is used in treatment of many body conditions (Christaki and Florou-Paneri, 2010). Proper processing techniques are required to preserve the bioactive chemicals (Eshun and He, 2004).

Handfilleting method for processing must be finished within 36 hours of harvest (Ahlawat *et al.,* 2011; Robert, 1997). The leaf after cutting into sections is treated with chemicals and then filtration is done by means of screening filters. Rich juice, virtu-

ally free of the laxative anthraquinones is formed (He *et al.,* 2002). To avoid enzymatic browning homogenization should be completed within 10–20 min (Ahlawat *et al.,* 2011; Gowda *et al.,* 1980).

Sterilization can be done with the activated carbon at high temperature in hot processing (Ahlawat *et al.,* 2011; Cerqveira *et al.,* 1999). All the steps of processing are without the application of the heat in cold processing (Ahlawat *et al.,* 2011; Coats, 1994). The gelis exposed to UV light followed by micron filtrationis another step of sterilization (Ahlawat *et al.,* 2011; Maret, 1975).

Conclusion

Aloe vera is a miracle plant. The demandis growing tremendously in the international market (Phanisri *et al.,* 2017).

Authors Contribution

Preparation of the manuscript (Namrata Kashyap and Budhesh Pratap Singh).

Declaration

The authors declare that they do not have any conflict of interest.

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