

Effects of Dehaulming in Potato (*Solanum tuberosum*) Cultivation: A Review

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Abstract— Potato is one of the most important commercial crops worldwide covering 20 million hectares cropping area. Series of cultivation practices are performed in potato cultivation where dehaulming is considered one of the prime-factors that affect the quality and size of tubers. It is also considered as a key factor in production of healthy potato seed in Seed plot technique methods. Dehaulming practice includes the act of detaching and defoliating the vegetative part lying above the ground of potato plant from the underground tuber. Effect of dehaulming is significantly found in the yield of seed tuber, the post-harvest quality of potato tuber and the disease, pest protection aspect of plants. The weight of tuber was found to be 384.20 g when haulm was cut at 65 days after planting (DAP), then significant increase in weight was found i.e. 533.00 g when the haulm was cut at 80 DAP. And the maximum seed yield was observed when dehaulming was done at 70 DAP i.e. 19.75 t/ha and similar to the non-seed yield. The post-harvest quality of tuber is also significantly improved when dehaulming was performed prior to harvesting. Mainly, the dehaulming practice when performed at 65 DAP was found comparatively safer from infestation and viral disease transmission through the sap sucking pest.

Keywords— Potato, Dehaulming, Tuber, Yield, Post harvest.

I. INTRODUCTION

Potato is one of most important commercial crops worldwide. With a total cropping area of about 20 million hectares globally, the potato is the fourth most important staple crop after rice, wheat, and maize (Stef de Haan et al,2016). The primary center of origin and diversity of potato crop is found widely prevalent in western region of South America (Hawkes,1990). The first domestication of potato was found to be in southern Peru and northwestern Bolivia between 4000 to 8000 BC. The gradual evolution of the diversity of potato in the farmer's hands is foretell to allow its higher adaptation to climate change and the increasing food security on the immoderate agroecology (John and Keen 1986; Zimmer, 2014).

Solanum tuberosum plant is herbaceous in nature which has height upto 0.4-1.4 m tall and it has prostrate to semi erect structure of plant (Spooner and Knapp, 2013). Stem may be hairless to densely hairy with purple green or mottled green in color. It has a single bear terminal leaflet with three to four large ovoid leaves (Spooner and Knapp 2013; Struik,2007).

The flowering pattern usually starts from branches near to the base of the plant and then proceeds upward. The flower remains open for 2 to 4 days, where the receptive stigma and pollen are produced for around 2 days (Plaisted,1980). The storage organ of *Solanum tuberosum* is tuber that is developed from the swollen underground stem, consisting of several eyes on tuber which are called buds that have potential to sprout and develop into new stem (Hoopes and Plaisted 1987). The tuber formation is much favored in short days. Among the entire cultivation practice dehaulming is considered one of the major practices that determines the qualitative and quantitative character of potato.

Dehaulming is the practice in which aerial parts of a plant are removed 10-15 days before harvesting ("Dehaulming in potato", 2018). Dehaulming can be done after the yellowing of aerial parts because yellowing of the vine indicates the maturity of the potato (Lutaldio et al, 2009). Timing of dehaulming varies according to varieties and in general, the varieties that are not disease resistant are dehaulmed earlier than the disease resistant varieties (Virtanen et al.,2014).

Generally, there are two methods of dehaulming and they are:

Mechanical methods:

- **Haulm cutting:** In this method, aerial parts are cut with sharp objects. Manual cutting takes around 40 man-hours per hectare and hence advanced haulm cutters are developed to increase field efficiency and cutting efficiency (Titiwa et al, 2019).
- **Haulm pulling:** Haulms are pulled instead of cutting in this method. Manual pulling is a time and labor consuming process. This method is most effective as it does not allow regrowth of foliage (Misener & Everett 1981; Halderson et al., 1988). There were more fragments of vines in harvested tubers and also tubers' exposure to light was higher in case of haulm pulling method (Halderson et al, 1988).

Chemical method: Through this method, various chemicals are sprayed in foliage, which leads to death of plants. Compared to other methods, it is quite slower ("Seed Potato Dehaulming Methods", 2019). Among various chemicals like sulfuric acid, dinoseb, diquat, endothal, etc., sulfuric acid showed the quickest effect with 42% of desiccation at day one after application (Haderlie et al, 1989). Compared to Glufosinate-ammonium, diquat had quicker effect on stem and leaf desiccation in 3 and 7 DAT, and after 14 DAT, both had same effect on leaf desiccation but stem desiccation was higher in case of diquat (Ivany, 2001). Chemical that is applied for haulm cutting also kills weed and thus this method has double advantage ("Vine kill: Method and timing", 2019).

Regrowth of foliage was observed upto 24% annually when only mechanical methods were used and little regrowth was observed even in chemical methods (Virtanen et al., 2014). So, it is better to use the combination of both mechanical and chemical methods for the most effective haulm destruction and shorter tuber maturation process (Zotarelli et al, 2019).

II. EFFECTS OF DEHAULMING

2.1. Effect of dehaulming on yield

2.1.1. Effect on tuber yield:

The yield and the starch content of tuber is found to have lower in content when the haulm cutting was done before the natural senescence of the plant at an early stage (Struik and Wiersema, 1999). The haulm cutting practice when performed at an early stage where there is low starch content in tuber will directly affect the vitality of tuber to generate new sprouts and roots for consecutive growing seasons. (Sabba et al, 2007). Basically, on a fresh weight basis the tuber growth is almost found to have occurred till 50 days so the tuber per hill parameter is less related to the dehaulming practice. The general tuber per hill number ranges from 12.08 to 15.06 (Beukama and Zaag, 1990). However, the tuber weight per hill increases gradually. According to the research done in Bangladesh, weight of tuber was found to be 384.20 g when haulm was cut at 65 DAP, then significant increase in weight was found i.e. 533.00 g when the haulm was cut at 80 DAP. However, the result of haulm cutting at 75 and 80 DAP gave statistically similar results i.e. 505.60g on an average. So according to the data the yield obtained was 28.02t/ha in haulm cutting at 75 DAP which is almost similar it was 26.02 tons for 70 DAP and the least was for 65 DAP (21.30 t/ha) (Mahumad et al, 2009). So on average a 10-14 days gap between the plant harvest and the dehaulming practice is suitable for the periderm maturity (Waterer, 2007). Also, the 10-14 days period is adequate for skin setting of the tuber which will definitely determine the plant protection tuber quality and seed quality of the yields (Halderson et al, 1988).

However in the northern Europe production condition, prime factor to control the tuber size, haulm cutting is considered as an important practice since tuber growth in long- day condition of north Europe is found to be higher and quicker than normal (Temmerman et al, 2002). Hence haulm cutting is mostly done on strictly immature plants while they may still be flowering which results in unsynchronized timing between the haulm cutting and foliage senescence or maturation of potato tubers (Viraten et al, 2014). In the environment where there is a short growing season, haulm killing is considered as a means for early harvesting, building up the tuber skin before harvesting and obtaining a suitable size of tuber (Struik and Wiersema).

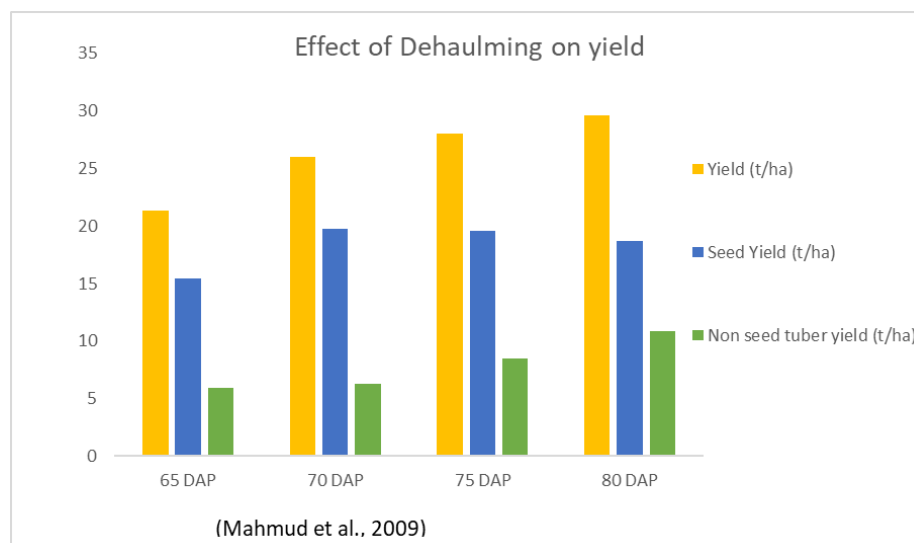


Fig 1: graphical representation of dehaulming effect on yield

2.1.2. Effect on seed production:

Quality of seed potato is primarily important in the aspect of yielding a crop and hence the seed production, harvesting (haulming and harvesting) and storage should be carefully carried out (Corrêa et al., 2007). When there is a favorable climatic condition, potatoes usually mature between the interval of 85 to 95 days after planting (Rashid, 1974; Ahmad 1977; Hussain, 1985). Maximum seed yield was observed when haulm cutting was done at 70 DAP i.e. 19.75 t/ha and similar to the non-seed yield. The yield data was statistically similar between haulm cutting at 75 and 80 DAP i.e. 19.56 t/ha and 18.69t/ha simultaneously. However, data as per the research conducted showed the poor seed yield when haulm was cut at 65 DAP i.e. 15.40t/ha. From the data, the maximum yield of non-seed tuber obtained from haulm cutting at 80 DAP was 10.89 t/ha which is equivalent to 37%. Also the ratio of seed and non-seed was found to be 1:0.318 for haul cutting at 70 DAP and the poor ratio was found for haulm cutting at 80 DAP that is 1:0.583) (Mahumad et al, 2009).

Dehaulming has significant effect on the emergence of seed potato. Those seed potato whose haulms were pulled out three weeks after flowering (75 days after planting) recorded emergence i.e 10.7 days however those seed potatoes whose haulms were allowed to mature naturally until the harvest (95 DAP) or were pulled out during the flowering time (50DAP) recorded slow emergence i.e (11.6-12.6days) (Virtanen, E., et al, 2013). The root and stem bulk production is also influenced by the dehaulming where the physiologically

older seed potato produced larger root and stem bulk at 95 days after planting and the seed potato whose haulm has been destroyed at the time of flowering, produced lower root and stem bulk (Virtanen, E., et al, 2013).

2.2. Effect of dehaulming on post-harvest and qualitative factors

Dehaulming hardens the potato tubers and increases the shelf life ("A Guide to Potato Production and Post Harvest Management in Kenya", 2013). After dehaulming, tubers are left in the field for 2-3 weeks for the skin to harden and such hardened skin reduces injuries during post harvest handling (Potato Vocabularies Explained, 9 Mar 2020). It generally takes 10-15 days for skin to set (Halderson et al, 1998 ; Virtanen et al, 2014). Respiration rate was minimum in tubers harvested after 90 days and dehaulmed before 10 days of harvesting (Mehta et al, 2003). Weight loss is one of the significant factors that determines the storability of potato tubers. Weight loss was seen minimum in potatoes harvested or lifted 9 days after dehaulming and maximum in potatoes harvested at 0 days after dehaulming (Nipa et al, 2013). However, starch content was found higher in the naturally senesced potato than in mechanically or chemically dehaulmed potato (Virtanen et al, 2014).

Dry matter content is considered a very important characteristic of potatoes when it is grown for industrial purposes. For processing potatoes into chips and French fries, dry matter content should be at least 20% (Gaur et al, 1999). Higher dry matter is associated with the crispiness

and lower oil uptake by the fried products (Pope et al,1971; Mehta et al, 2003). Potato with lower dry matter is good for canning purpose (Kumar et al, 2013). There is a significant effect of dehaulming in dry matter content of tubers (Neenan,1965). Mean dry matter increased when dehaulming was delayed from 70 DAP to 80 DAP (Marwaha et al, 2012). Dry matter weight percentage of flesh of potato was found to be 20.55, 21.28, 22.31, 24.60 and 27.32% in the potato harvested after 12 days after dehaulming and 12.85, 13.52, 15.52, 16.55 and 18.81% harvested after 0 days after dehaulming at 0, 30, 60, 90 and 120 days after storage respectively (Nipa et al, 2013).

Potato should have reducing sugar less than 100mg/100gm for development of proper color in chips (Marwaha et al, 2005). When the amount of reducing sugar is high, it

promotes Millard's reaction and results in darker chips and also in formation of a compound called acrylamide (Kumar et al,2013) which is a neurotoxin and a carcinogen (Vainio,2003 ; Bethke et al, 2010). When dehaulming was delayed from 70 to 90 DAP, there was significant reduction in the reducing sugar level, with increase in quality of tuber (Marwaha et al, 2012).

Phenolic compounds are generally found in the skin of potatoes and major compounds are phenolic acids and flavonoids (Akyol, Hazal, et al, 2016). Such compounds cause enzymatic discoloration after cutting or peeling (Marwaha et al, 2010). Total phenol content is seen lower when dehaulming is done after 70 DAP and highest when done after 90 DAP (Marwaha et al, 2012).

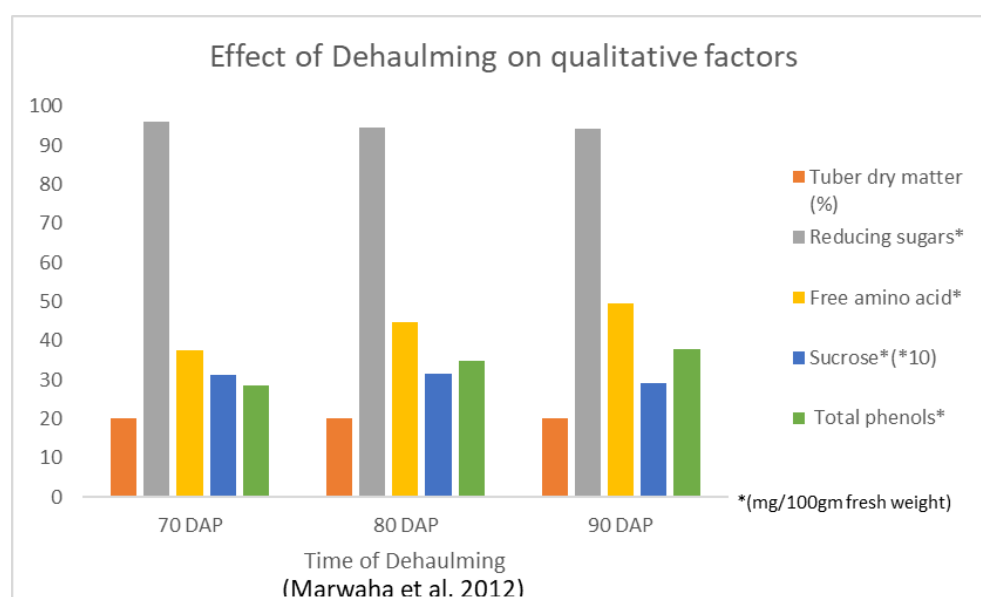


Fig.2: Graphical representation of dehaulming effect on qualitative factors

2.3. Effect on plant protection:

Different genera of different soil borne seed borne pathogen and many bacteria and fungus like *Rhizoctonia solani* (black scurf), *Phytophthora infestans* (late blight), *Phoma foveata* (gangrene) and *Verticillium dahliae* (Verticillium wilt) as well as bacterial diseases are controlled through the practice of haulm killing (Kempenaar & Struik 2007).

Several researches have been conducted to maximize benefits of haulm killing and minimizing soil transmitted and seed borne disease in seed potato production (Virtanen et al, 2014). However some of the haulm killing methods have

been found to increase the plant disease incidence (Kempenaar et al, 2008; Dijkstra, 1998). Black scurf is most prevalent in case of mechanical- chemical dehaulming practices (Virtanen et al, 2014). Cutting the stem along with chemical haulm killing aided with the extended period of time between dehaulming and plant harvesting increases the incidence of black scurf disease (Dijkstra, 1988). Also, Dijkstra explained that sclerosis formed on the surface of tubers due to the formation of water- insoluble components will ultimately make tubers more prone towards the disease. Immature tubers are more prone towards microbial infection

and their resistance gradually increases with maturity (Hide and Lap wood, 1992). Pathogens can attack foliage, root systems and tubers, therefore disease and its control can be important throughout the crop cycle. Majorly, the dehauling practice when performed at 65 DAP was found comparatively safer from infestation and viral disease transmission through the sap sucking pest (Mandal et al, 2020). According to the study conducted in New Alluvial Zone of West Bengal, it was concluded that for quality seed production and less disease pest incidence use of 50cm * 15 cm spacing along with haulm cutting at 65 DAP, while planting has to be done in the first week of November (Mandal et al, 2020).

Also, research has found that the incidence of aphids as a vector which carries potato leaf roll virus and the potato tuber moth infestation is controlled by dehauling and plant part before harvesting. Generally, dehauling is done in crop immediately when the aphids cross the critical limit of 20 aphids per 100 compound leaves (Awasthi LP, 2017). Also, some research has explained that the viral incidence was 1% which is regarded to be within permissible limit when the haulm cutting was done by Dec 25 than after the aphid buildup (Awasthi LP, Verma HN, 2017). Thus, the maximum mitigation of crop damage from the leaf roll and severe mosaic was obtained when the seed crops were planted at the end of October and haulm were cut by date when the critical limit of vector is just surpassed (Khurana et al, 1997).

III. CONCLUSION

Potato has always been one of the most important foods. It can be consumed as a vegetable or can be processed into various types of products. There are many different cultivation practices and in this article, we discussed dehauling and its effect on yield, post harvest and qualitative factors and in plant protection. Haulms are destroyed when vines turn yellow indicating the maturity of the plant. Haulm destruction is done by either cutting, pulling or chemical application. Proper dehauling helps to increase the yield both in terms of tuber size and seed tuber and also minimize injuries during post harvest handling by thickening of skin. Reducing sugar, phenol content, dry matter, free amino acids, etc. determine the quality of potato in industrial level and dehauling helps to maintain optimum level for these elements. In addition to that, it also plays a significant role in plant protection. Various pathogen carrying pests can

be avoided by dehauling at the right stage that will help to produce disease free tubers.

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