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# Varietal evaluation of different potato (*Solanum tuberosum* L.) varieties

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**Abstract**
Potato is the one of the most stable food crops of Nepalese people. It occupies first position in productivity and second in total production as well as fifth in total area coverage among the food crop grown in Nepal. Potatoes are grown widely from the southern terai at altitudes below 100 masl to the northern mountains as high as 4,000 masl. There are various factor leading to low or decline the production of potato as compared to other leading country. In case of Nepal, unavailability of region-specific variety and susceptibility of late blight of potato are the major constrains among other. This review is an attempt to review all the yield and yields attributing characteristics of different potato varieties that are grown in Nepal. This review will cover number of shoots per plant, plant height, plant uniformity, disease infestation, plant vigor etc. and yield attributing characters data i.e., tuber number per plant, tuber weight per plant, yield per plot, yield per hectare, tuber sizes by number and weight were recorded throughout the research.

**Keywords:** Potato, trial, variety, Nepal

## 1. Introduction

Potato (*Solanum tuberosum* L.) is one of the staple food crops of Nepalese people. It occupies the first position in productivity, second in total production, and fifth in area coverage among the food crops grown in Nepal (MoALD, 2020) [55]. In the global scenario, it is the most important food crop surpassed by rice, wheat, and maize, and is consumed worldwide as an important non-cereal staple crop. In Nepal potato is cultivated in 193,997 ha of land and gives the production of 3,112,947mt with productivity of 16.05 mt/ha. (MoALD, 2020) [55]. Some major districts contributing to potato production in Nepal are Illam, Jhapa, Bara, Dolakha, and Kavre (CBS, 2019) [15] Out of the total area under the cultivation of potatoes about 19% lies in the high hills and mountains, 44% in the mid-hills and 37% in terai (NPRP, 2019) [58] It is cultivated as a winter crop in the tropical and subtropical region and as summer crops in the temperate region of Nepal (Dhakal, 2002) [21]. Compared to the productivity of potatoes in Nepal's neighboring countries like China, India, and Bhutan, Bangladesh has a productivity of 18.8mt/ha, 22.6mt/ha, 10.6mt/ha, and 20.4 mt/ha respectively (FAOSTAT, 2020) [108]. Similarly, potato productivity in The United States of America and The Netherlands is 49.8 mt/ha and 36.6 mt/ha (FAOSTAT, 2020) [108].

Nepal is one of the top countries where potato contributes subsequently to the human diet. The demand for potatoes is increasing with the demand for value-added products of it. Potato has a place in the everyday diet but it varies with altitude from an expensive vegetable in the terai to a main staple food in the high hills. It has a significant role in income generation, food production, and overall poverty alleviation as it has a short crop duration and is a high market intended crop. Potato plays an important role in food security and livelihood due to its high cash, food, and nutritive value (Gautam *et al*., 2011) [36].

Yield in the country is about 1.5 times low compared to developed countries (Upadhyay *et al*., 2020b) [78]. There are various factors leading to the decline or low production of the potato compared to the leading countries in the world. According to the farmers, there occurs a lack of seed tubers in bulks during the growing season for the plantation which mainly affects the farmers from getting benefits of new varieties in the pivotal potato growing zone. Ghimire (2005) [38] mentioned dissatisfaction among the farmers regarding the available potato varieties because they dearth of climate resistance and are not early maturing varieties. Apart from the above-mentioned reason, low productivity of potato is triggered due to various factors such as diseases, insect pests, irrigation, fertilizer, varieties and management practices (NPRP, 2018). Among above the major factors which were identified by National Potato Research Program were inadequate cultivation practices with the soil-cultivars-climate complex, low yielding varieties, insufficient soil fertility management practices, inadequate control measures for major diseases and insect pests, and lack of location-specific potato varieties (NPRP, 2015; Upadhyay *et al*., 2020) [60, 78]. Alongside it, the area of modern varieties cultivated in Nepal is much lower in comparison to the most potato-producing countries in Southeast and South Asian countries (Gatto*et al*., 2018) [35].

In Nepal, the western terai farmers cultivate both improved as well as local varieties of potato. They usually grow a mix of these varieties according to their characteristics and suitability.Most of the farmers do subsistence agriculture and they cultivate local varieties of potato. The majority of the farmers are small landholder having an average of 0.65 ha of land size which requires commercialization for the better economic growth and development of the least developed countries which depends on agriculture (Pingali & Rosegrant, 2013; Timmer, C. P. 1997; Von Braun & Kennedy, 1994) [63, 76, 79]. With the help of the use of scientific technology, there is the potential to increase the productivity of potatoes (Manjunah, *et al*., 2013) [54].

Among the various constraints including biotic and abiotic causes Late blight is one of the major (Hardy *et al*., 1995) [41] cause of reducing yield in almost all potato growing area among the world (CIP 1996, Fry *et al*., 1997) [18, 33] costing over € 12 billion in crop losses and control measures (Haverkort*et al*., 2009) [42]. In Nepal the disease was first reported between 1883 and 1897 (Shrestha, 1976) [69] and has become epidemic since mid-1990s. It appears in epidemic condition in the high hills every year but in the plains (Terai) it occurs sporadically (Shrestha *et al*., 1998) [71]. Sometime about 50-90% loss have been reported in the terai similarly more than 75% in high hill (Shrestha, 2000) [70]. In the high hills losses have been encountered more than 75% and, in the Terai, losses have been reported 50-90% in some years (Shrestha, 2000) [70]. A nationwide crop failure due to late blight was observed in 1996 (Dhital& Ghimire, 1996) [22]. When yield loss due to late blight is estimated to a minimum level of 20%, the national economic loss reaches up to NRs 1.8 billion (USD 25 million) annually (Sharma & KC, 2004). The genus Phytophthora literally translated from Greek words: Phyton = plant and Phthora = destroyer; and in case of *P. infestans* this name makes sense. The pathogen seriously infects potatoes as well as tomatoes and some other members of the family Solanaceae (Agrios, 2005) [1].Potato late blight is most destructive, however, in areas with frequent cool, moist weather (Agrios, 2005) [1]. When cool and humid conditions are present for long periods of time, pathogen sporulation increases considerably (Crosier, 1934) [19]. Temperature influences spore germination, mycelium growth, inoculum and survival of the pathogen. Temperatures ranging from 12 to 24 °C favor sporangia germination which increases the pathogen load and disease outbreak (Fry & Mizubuti, 1998) [32]. In cases of severe incidence, even the stem and tuber are infected. It appears in epidemic proportion every year during winter season in the Terai and inner Terai regions and during summer season in the hills causing huge losses (Shrestha, 1976) [69].

## 2. Overview

### 2.1 History and Overview of Potato

Potato (*Solanum tuberosum* L.) was assumed to be originated from the Andes Mountain range of South America, the border between Bolivia and Peru. It is believed that 200 years before Christ, potato cultivation started from there. It has since spread around the world and become a staple crop in many countries. The potato was introduced to coastal southern Asia in the late sixteenth or early seventeenth century by European (initially Portuguese) mariners, but the historical record for roughly the following two centuries is complicated by the word itself. "Potato" is derived from "batata," the Carib term for sweet potato (*Ipomoea batatas*), which preceded the potato by eighty years in its introduction to Europe from its area of origin in the American Andes. Both crops were introduced by Europeans throughout Asia and Africa continent, but documented references to "batata" during this era could be referring to either (Purseglove, 1968) [126].

Firstly, the cultivation of potatoes in Nepal is noticed in 1793, in records by a British Colonel Kirkpatrick (Akius *et al*., 1990, Katri & Rai, 2000) [115]. For Over 150 years it remained a relatively minor and unrecognized crop in Nepal until the first official attempt to improve potato production in Nepal occurred in 1962 under a program sponsored jointly by Nepal and India.In 1972 the National Potato Development Program was founded by the Government of Nepal, focusing on the production of higher quality potato seed tubers. Potato has become the fastest-growing staple crop in Nepal over the past few decades.

### 2.2 Cultivation of Potatoes in Nepal

Potato is the major crop of Nepal and it is widely grown throughout the country, from the southern Terai at altitudes below 100 masl, to the northern mountains as high as 4,000 masl. Generally, the cultivation of potatoes lies between 200-2000masl (Anonymous, 1997) [116]. Generally, planting of potatoes is done on Ashwin to Mangsir in Terai (<300) similarly to Bhadra to Falgun in the hill (>300msl), and harvesting is done on Magh to Chaitra in terai similarly to Mangshir to Jestha in the hill.

### 2.3 Cropping Calendar

The great agro-ecological diversity of Nepal allows for potato cultivation to occur somewhere at any time of year. Potato is a winter crop in the Terai and low hills, a spring, and autumn crop in the mid-hills, and a summer crop in the high hills and mountains. The duration of a crop is variable by variety but is longer at higher altitudes. The generalized cropping calendar is summarized (Dhital, 2000) [114] as follows:

#### 2.3.1 Cropping calendars by altitudinal zone

In Nepal the growing of the potato varied with the geographical location and it is shown in the table below.

**Table 1:** Cropping Calendar for Potato Cultivation in Different Region of Nepal

| Zone | Altitude (masl) | Planting months | Harvesting months |
|---|---|---|---|
| Terai | Up to 350 | October - November | January - February |
| Low hills | 350 - 1,000 | September - December | December - March |
| Mid hills | 1,000 - 1,800 | January - February | April - June |
| | | August - September | November - December |
| High hills | 1,800 - 2,200 | February - March | July - August |
| | 2,200 - 3,000 | March - April | July - September |
| Mountains | 3,000 - 4,000 | Late April - Early May | September - October |

### 2.4 Varietal Evaluation of Potato

Cultivars include landraces and varieties which are developed by breeders (Shrestha *et al*., 2020) [102]. The adoption of improved potato varieties highly influences the income of farmers and the nation's nutritional security (Ghimire, 2005) [38]. Variation in characters in different varieties shows variation in performance towards natural resistance to pests and diseases, and climatic conditions (Shrestha *et al*., 2020) [102]. High yielding varieties of potato is one of the desirable characters by farmers for successful cultivation and apart from high yield area specific varieties are also important (Gotame *et al*., 2021) [91]. Nepal agriculture research council is responsible for varietal development (Gairhe *et al*., 2017) [120] and the varieties possess the high yield potential and spread of these varieties can greatly enhance the national potato production (Kafle & Shah, 2012) [109]. Gairhe *et al*. (2017) [120] also reported that improve varieties possess the high yield potential and its choice is most critical for determining the productivity. Improvement in the quality and composition of different varieties of potatoes is a necessary condition for the intensification of potatoes (Voronov *et al*., 2019) [110]. However not all the varieties are sufficiently adapted to different climatic zone and lead to the yield losses thus particular variety suited to the particular location's weather and other environmental factor should be selected (Smirnov, 2018) [111]. Eaton *et al*. (2017) [24] reported the different varieties of potato either improved or local are responsible for yield potential and result in variable yield performance thus it is important to evaluate the varieties. Getie *et al*. (2018) [37] also reported the variable performance on different potato varieties on yield and quality of potato. Number of improved varieties have been released with major focus on high tuber yield, wide adaptability and disease resistant as the varieties are responsible for these traits or characteristics (Tessema *et al*., 2020) [75]. Many authors reported differential performance of potato varieties thus it is crucial to evaluate them at a different location. The variation in different traits of the potato was influenced by the interaction between variety and environment and concluded that the differential performance of varieties could be observed across different location (Tessema *et al*., 2020) [75]. Some other quality traits of potato varieties could be influenced significantly by the growing environment, variety and their interaction in Eastern parts of Ethiopia (Tekalign, 2011) [74].

### 2.5 Vegetative Component

Ahmed *et al*. (2017) [2] observed that planting different varieties potato tuber at proper timing results early emergence of potato and better seedling establishment. Six modern varieties of potatoes were observed and found that different variety possess different morphological characters. Among the six different varieties, Asterix was found to produce the highest plant height (61.33 cm) followed by Diamant (59 cm). Asterix was found with the highest number of main stems per hill followed by Granola (5.5) and Diamant (5.17). Cardinal was found with the lowest number of stems per hill. (Eaton *et al*., 2017) [24]. Shrestha *et al*. (2020) [102] found that days to germination, plant height, and average number of leaves, branches and stem girth were affected by different varieties but not by mulching. Cardinal, Panauti local and M.s 42.3 varieties germinated slower than Janakdev and Cardinal. The plant height of Panauti local and Janakdev was found taller than other varieties but their height was statistically similar. Cardinal and MS-42.3 was observed to possess the highest number of branches whereas least in Khumal Bikash in 45 days. Seven potato cultivars were observed during winter and five potato cultivars were observed during autumn season and found that during winter plant height and no of leaves per plant were affected by cultivars whereas no of shoot and pant height were affected during autumn. Highest plant height and shoot length were found in Belete cultivar (Fetena & Eshetu, 2017) [28]. Eight potato varieties were observed under the irrigated condition for tuber and vegetative growth, Chubak variety was found with the lowest plant height whereas Belete variety was found with highest. Average tuber number was found highest in Haryung followed by Gown (Chindi *et al*., 2019) [16]. Commonly grown nine potato varieties were observed, Janakdev was found with the minimum canopy and tallest plant height (57.25 cm) at harvest and Cardinal with the lowest plant height (50.40 cm). Highest no of leaves per plant was observed in Janakdev (109.8) and lowest in Cardinal. In Cardinal highest number of main stems per hill was recorded and lowest in Khumal upahar (Banjade *et al*., 2019) [6].

#### 2.5.1 Plant Uniformity

Nine different varieties of potato were observed which were matured in less than 100 days. Some of the varieties of the potato showed variations in flowering and maturity but some of the varieties such as Bubu and Menagesha showed uniformity for 50% flowering (Tessema *et al*., 2019) [112]. Six Different cultivars were observed, among these varieties no of stems per hill ranged from 4.67 to 6.17 and was not statistically different from one cultivar to another (Eaton *et al*., 2017) [24]. Experiment was conducted in 21 breeds in Hungary, Poland and Spain in 2 years for the evaluation of tuber yield, starch content and yield and found that stable trait expression was found in 6-11 varieties. Stable and unstable responses was analyzed by using GE interaction (Flies *et al*., 2014) [118]. Five varieties introduced from republic of South Korea and three nationally released varieties was evaluated for vegetative growth and yield, Belete variety was found with the highest plant height (65.43 cm) and stem number of 6.58 per hill and Chubak with lowest plant height (26.22 cm) and lowest stem number 3.57 per hill (Chindi *et al*., 2020) [17].

### 2.5.2 Plant Height

In response to the plant height there were observed the significant variation among varieties of the potato with the result of tallest height (61.33 and 59 cm) on the variety Asterix and Diamant respectively (Eaton *et al*., 2017) [24]. Many author conceived that the potato germplasm had difference response of plant height in different part of the world (Asefa *et al*., 2016; Basavaraj *et al*., 2005) [3, 7]. Highly significant effect of environment, cultivars and their interaction on plant height were observed in Eastern Ethiopia (Bilate & Mulualem, 2016) [11]. Varieties showing differential result on plant height could be due to genetic and inherent characters (Bhuwneshwari *et al*., 2013; Kumar *et al*., 2008) [10, 51].

### 2.5.3 Plant Vigor

Vigor of seed material determines the proper growth of plant and future productivity. There are different methods for determining the vigor of the seed but there is lack of standardization for vegetative forms of seed material (Krystyna. 2013) [127]. Different six varieties were observed and found that Asterix produces highest plant height (61.33 cm) followed by Diamant (59 cm) (Eaton *et at*. 2017) [24]. Soil Improvement during cropping increased the vigor of the potato plant as leaf area, chlorophyll content, root and shoot biomass was found higher in the improved soil (Larkin *et al*., 2021) [52].

### 2.6 Maturity Characters

In order to develop suitable production scheme and marketing plan, traits like Numbers of days to emergence, flowering and maturity are considered important for potato producers(Khalafalla, 2001) [46]. Fantaw *et al*. (2019) [26] reported that the varieties could affect the 50% emergence, flowering and maturity and it provide basis for selection of late or early maturing varieties depending upon the rainfall duration, temperature and labor availability. Early flowering indicate the beginning of tuberization at an early stage and this varies with varietal characters of the potato (Carrie *et al*., 2014) [14]. It was found that the varieties affect the days to maturity which support farmers to increase efficiency based on the land vs time use that ultimately have possible contribution to intensify production on unit land (Fantaw *et al*., 2019) [26]. The variation in length of growing period among varieties might be due to the difference in genetic makeup (Girma, 2012) [39] as flowering and maturity both are heritable traits (Asefa *et al*., 2016) [4]. The correlation study between days to emergence with days to maturity represent the positive and significant relation and it was reported that the delay in tuber initiation prolongs with days to flowering (Fantaw *et al*., 2019) [89]. Tessema *et al*. (2020) [75] reported that the among the different varieties of potato examined, **t**hree varieties Challa, Bubu and Belete had delayed maturity without significant differences between each other and Marachere. Among varieties studied by Kolech *et al*. (2017) [50], some of them exhibited the variation in the flowering and maturity at two different location.

### 2.6.1 Days to tuber initiation

The days for initiation of tuber is widely consider a key development stage on plant life, having profound implications for subsequent growth and development. (Brien *et al*., 1998) [122]. It was the third stage of growth, during this stage tuber were forming at stolon tips, but are not yet enlarging. If we observe potato plant at this stage, tuber would be about the size of jelly bean and would like a mini potato. This occurs between early and late June depending on location, planting date, climate, soil type and variety (Bradely, 2009) [119]. Usually, initiation of flowers occurred before tuber initiation and within two weeks of emergence of flower tuber initiation occur but earlier in some varieties. There was little influence of photoperiod on the time to initiation of flowers and tubers in most experiments but, with low levels of radiation, flowering was completely inhibited in the variety Maris Piper (Firman *et al*., 2009) [117].

### 2.6.2 Days to maturity

It is the last stage for the growth and development of potato plant. In this stage vines turn yellow and lose leaves, photosynthesis gradually decreases, tuber growth rate slows and the vines die. Maturity stage may not be occurred on growing a long season variety like Russet Burbank (the potatoes you most commonly used for baked potatoes) in a production area with a short growing season like Wisconsin. In that case, the plant is killed using an herbicide so the tuber can grow a little bigger before harvest. Some other varieties like Goldrush and Norkota, however, will complete this stage and there will be almost nothing left of the plant but decayed stems and leaves when it is time to harvest the potatoes. Red potatoes are cut short of their maturation period because consumers like eating the small red potatoes and farmers can't sell their red potatoes if they got too large (Bradely, 2009) [119].

### 2.7 Disease Incidence

The causal organism of potato late blight i.e. *Phytophthora* literally means 'plant destroyer', was first coined by Anton de Bary in 1876, when he investigated the potato disease that set the Great Irish Famine in 1845-1847. The science of plant pathology was born and the fungus got its final title of *Phytophthora infestans* (Mont.) de Bary (Dowley, 1997) [23]. In dry weather the activities of the pathogen are slowed or stopped and when the weather becomes moist again the oomycete resumes its activities and the disease once again develops rapidly (Agrios, 2005) [1]. Late blight is the most important (Hardy *et al*., 1995) [41] and major yield-limiting disease in all potato-growing areas of the world (CIP, 1996; Fry *et al*., 1997) [18, 33]. The disease was first reported in Nepal between 1883 and 1897 (Shrestha, 1976) [69] and has been appearing in epidemic proportions since mid-1990s. It appears in epidemic proportion in the high hills every year but in the plains (Terai) it occurs sporadically (Shrestha *et al*., 1998) [71]. In the high hills losses have been encountered more than 75% and, in the Terai, losses have been reported 50-90% in some years (Shrestha, 2000) [70].

By 1845, late blight was found from Illinois to Nova Scotia and from Virginia to Ontario. The disease then crossed the Atlantic Ocean with a shipment of infested seed potatoes from the United States to Europe, mainly to Belgian farmers, in 1845 (Reader, 2008) [65]. Once *P. infestans* reached Ireland, a country that was strongly dependent on potatoes as a main source of food and was predisposed to adverse political, social, and economic factors (Kinealy, 1994) [48], wide infestation of potato by *P. infestans* resulted in a near-complete destruction of the crop. Once an unprotected potato field (field, greenhouse, and/or plastic-cover cultures) is infected by *P. infestans*, the whole crop can be devastated within 7 to 10 days (Fry, 2008) [121]. Economic losses may be in the form of reduced yield, lower quality of the fruit (such as low specific gravity), and diminished storability (Fontem *et al*., 1996) [31].

NPRP has released and recommended several varieties such as KufriSindhuri, Desiree, Cardinal, Janak Dev, Khumal Rato and IPY8for terai and inner Terai region but these varieties could not be adopted widely in these areas due to high incidence of diseases and insects, poor keeping quality and low yield. (Khatri *et al*., 2010) [123]. Nine potato varieties (7 local and 2 check) were observed for resistance against the late blight and found that Lumlekalo and Janakdev were resistant in the field, Hale, Rato, LumleSeto, Kalo and Seto were moderately resistance and Phul was found susceptible. Janakdev was found highly resistant to late blight in detached leaf essay. (Shrestha *et al*., 2019) [73]. (Asefa *et al*., 2016) [4] conducted the experiment at Sinana Agricultural Research Center, Southeastern Ethopia and found that on farmer's cultivar Kellacho Late blight appeared faster i.e 45 days after planting whereas appeared late in advanced cultivar CIP-392640.524 i.e. 74 days after planting.

## 2.8 Yield and Yield Attributing Characters

Production and productivity also can be determined by the specific varieties (Banjade *et al*., 2019) [82]. For processing, marketing demand, human consumption, and planting of the seed, the number, and size of the tuber are considered economically important characteristics (Kirkman, 2007) [49]. Different researchers reported that the various potato varieties exhibit differential potential on yield and yield components across locations (Bilate & Mulualem, 2016; Fantaw *et al*., 2019) [11, 89]. Parameters like increment of plant height, large-sized tuber yield, marketable tuber number and yield, and prolonged time of maturity have relation to the yield variation among varieties because of their contributing role in higher total tuber yield (Getie *et al*., 2018) [37].

### 2.8.1 Tuber number per plant

Number of tubers plant$^{-1}$ was recorded significantly variable among different variety (Luitel *et al*., 2020; Rangare & Rangare, 2017) [53, 64]. For average tuber number per hill in Eastern Ethiopia, a significant variation between varieties, growing environment and their interaction in potato was recorded by (Berhanu & Tewodros, 2016; Habtamu *et al*., 2016c; Seifu & Betewulign, 2017) [84, 94, 101]. Average tuber number/hill was found to be significantly different among different varieties of potato evaluated at Holetta Agricultural Research Center and AdeaBerga sub-station during the 2017 (Tessema *et al*., 2020) [75]. Eaton *et al*. (2017b) [87] also reported the similar results. Among the 24 potato variety examined, significant differences were observed in the number of tubers per plant due to genetic variation (Asefa *et al*.; 2016) [81]. Variety of potato evaluated in an experiment revealed that the variety were significantly variable for the parameter like Plant height, stem number and tuber number per hill (Getie *et al*., 2018) [37]. In an experiment of Khan (2019) [95], total number of tubers/plant revealed that CIP-5 produced maximum number of tubers/plant (31.70 tuber), which was statistically at par with CIP-9 (25.30 tuber).The variation in the parameters like total number of tuber per plant is associated with plant genetic makeup and environmental conditions (Eaton *et al*., 2017a; Subarta & Upadhya, 1997) [87, 103]. Similar result was mentioned in the report of (Masarirambi *et al*., 2012) [98].

### 2.8.2 Tuber number per plot

Fetena & Eshetu (2017) [29] reported that the different variety of potato showed variable performance towards Tuber number per plot. The variable was also reported by at Dailekh Nepal where the potato varieties evaluated result significantly different on tuber number per plot (Luitel *et al*., 2020) [53]. Average fresh fruit weight of tuber per plant and total tuber number per plant among different potato varieties was not significantly different ($p>0.05$) at Assosa area, though it was highly significantly ($p<0.01$) influences at Maokomosite (Bekele & Ebrahim, 2020) [8]. The results showed that total tuber number per plot was significantly ($p>0.05$) affected by varieties at Assosa whereas it was highly significantly ($p<0.01$) affected by different varieties at Maokomo (Bekele & Ebrahim, 2020) [83].

### 2.8.3 Tuber weight per plant

Weight of tuber has an important role in yield (Khan, 2019; Werij, 2011) [95, 106] and Patel *et al*. (2008) [99] concluded that the large size/weight tubers may be due to the result of rapid plant emergence and better plant growth. The fresh weight of tubers per plant and dry weight of tubers plant$^{-1}$ were found to be significantly variable among the different variety evaluated by (Rangare & Rangare, 2017) [100]. The performance of different potato varieties was significant in terms of number and weight of tuber per plant (Banjade *et al*., 2019) [5]. Fantaw *et al*. (2019) [89] reported that the varieties affected the number of tubers per plant, and tuber yield and also mentioned that the variety with more tuber number had a lower average tuber weight.

### 2.8.4 Tuber weight per plot

Tuber weight per plot exhibit differential results among different varieties of the potato (Eaton *et al*., 2017b; Fetena & Eshetu, 2017) [87, 28]. Similarly, the effect of potato variety was found to be significantly different for the tuber weight per plot (Banjade *et al*., 2019) [6].

### 2.8.5 Tuber yield per hectare

Among the 17 potato varieties evaluated in Ethiopia, the presence of genetic differences for tuber yield per hectare were also reported by (Habtamu *et al*., 2016a, 2016b, 2016c; Wassu, 2017) [92, 93, 94, 105]. Marketable tuber yield, and total tuber yield were significantly variable among different variety of potato used in the study and concluded that the high heritability along with high genetic advance was recorded for the traits like unmarketable tuber yield per plot, dry weight of tubers (g per plant) and total tuber yield per plot(Rangare & Rangare, 2017) [10]. Differential result of potato varieties in tuber yield was also reported by many scholars in Ethiopia (Seifu & Betewulign, 2017; Wassu, 2016; Zerihun, 2016) [101, 104, 107]. Similar result of differential performance of total tuber yield (t/ha) and, marketable tuber yield (t/ha) was reported (Das *et al*., 2021; Eaton *et al*., 2017b; Elfinesh, 2008; Luitel *et al*., 2020; Tessema *et al*., 2020) [85, 87, 88, 97, 75]. A significant positive correlation was obtained with average tuber weight, average number of stems, and plant height with average number of tubers and concluded that the varieties with higher average tuber size/weight, taller plants and produce more stems and tubers increased tuber yield (Asefa *et al*., 2016) [81].

From the study carried out in 21 potato variety moderate to high-level heritability was reported for the quantitative characteristics including tuber yield (Ozturk & Yildirim, 2014) [62]. The results showed that total tuber yield was significantly ($p$>0.05) affected by varieties at Assosa whereas it was highly significantly ($p$<0.01) affected by different varieties at Maokomo (Bekele & Ebrahim, 2020) [83]. Significantly varied ($p$<0.001) result were reported on the tuber yieldamong variety (t/hac) (Kwaka *et al*., 2017) [96].

### 2.8.6 Tuber sizes by number and weight

It is considered that the potato tuber size and weight is an important attributing characters for the consumer and retailer and Khan (2019) [95], and Werij (2011) [106] reported the variable performance of the variety on total number of tuber/plant. Evaluation of different variety of potato in the field of Dailekh exhibited highly significant effect on parameters like non-marketable and marketable tuber weight (Luitel *et al*., 2020) [97]. Tubers were also graded as marketable (>20 g) and non-marketable (<20g) and recorded variable performance among different varieties (Fetena & Eshetu, 2017) [29]. In an experiment by Eaton *et al*. (2017b) [87], significant difference was observed in different grades of tuber by weight among varieties of potato. The significant effect of varieties on small <25g), medium (25-50g), and large (>50g) tuber class and tuber yield (ton/ha) was also reported (Banjade *et al*., 2019) [82]. Variety of potato evaluated in an experiment revealed that the variety were significantly variable for Large, medium and small-sized tuber yield and result showed positive and significant correlation between total tuber yield and large-sized tuber percentage (r= 0.52*), (Getie *et al*., 2018; Girma & Niguisse, 2015) [37, 90].

## 3. Conclusion

Nepal is one of the top countries where potato contributes subsequently to the human diet. Potato has a place in the everyday diet but it varies with altitude from a common vegetable in the Terai to a main staple food in the high hills. It has a significant role in income generation, food production, and overall poverty alleviation as it has short crop duration and is a high market intended crop. Potato plays an important role in food security and livelihood due to its high cash, food, and nutritive value. But Yield in the country is about 1.5 times low compared to developed countries, various factors leading to the decline or low production of the potato compared to the leading countries in the world. Unavailability of region-specific variety and susceptibility of late blight of potato are the major constrains for its production. Thus, use of resistant and location specific variety is the major solution to solve the issue among other different solution. However, further research should be carried out for the confirmation of host resistance to late blight including greenhouse screening methods for at least two successive seasons. Variety identified and released as resistant may become susceptible after continuous growing in the same region over the years. So, farmers should change their variety from time to time.

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