Ann. Bangladesh Agric. (2016) 20(1 & 2) : 95-105 *ISSN 1025-482X (Print)*
2521-5477 (Online)

DRY MATTER ACCUMULATION PATTERN IN DIFFERENT COMPONENTS OF FOUR POTATO VARIETIES

O. Howlader, M. A. Hoque* and M. M. Hossain

Abstract

The experiment was conducted at the research field of the Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during the potato growing season of 2013-14 with four potato varieties viz., Asterix, Cardinal, Diamant, and Granola. The purpose of this study was to evaluate the pattern of dry matter accumulation pattern in different organs at different days after planting (DAP). Results revealed that dry matter accumulation in the plant parts (leaf, stem, root, and tuber) showed an increasing trend from 30 to 80 DAP irrespective of varieties. All the varieties produced maximum stem and leaf dry weights at 80 DAP but insignificantly. Asterix and Cardinal attained maximum root dry mass at 80 DAP. But in case of Diamant and Granola, it was maximum at 70 DAP and decreased at 80 DAP. Rate of dry matter accumulation to tubers from 30 DAP to 60 DAP increased linearly and after that increased steadily. At 30 DAP, maximum dry matter was found to be accumulated to leaves followed by that of stem, root, and tuber. This trend was changed from 50 DAP till harvest, and maximum dry matter was accumulated to the tubers followed by that of leaf, stem, and root.

Keywords: Dry matter, potato, leaf, stem, root, tuber.

Introduction

Potato *(Solanum tuberosum)* is the second largest food crop in Bangladesh next to rice and has recently occupied an important place in the list of major food and cash crops of Bangladesh (Ali and Haque, 2011). In fact, short cycle of potato frees the land for cultivating other crops (Hoque *et al.,* 2012). In the year 2011-12, the total potato production in Bangladesh was 8.21 million tons from an area of 0.43 million hectares and average yield was about 19.08 tons per hectare. Whereas, in the year 2012-13, total production raised up to 8.603 million tons from an area of 0.44 million hectares and average yield was 19.38 tons per hectare (Anon., 2014). The area and production of potatoes are increasing day by day due to its higher demand and profitability. The annual growth rates of area, production, and yield of potato were estimated as 7.14%, 9.90%, and 2.76%, respectively, during 1989-1990 to 2008-2009 (Miah *et al*., 2011).

Potato is grown more or less in all the districts of Bangladesh, but produced better in the districts of Munsiganj, Bogra, Rangpur, Dinajpur and some parts of greater Comilla (Anon., 2014). In the last few decades, several dozens of high yielding varieties (HYV) of potato were brought to Bangladesh and tried experimentally under local conditions before they were recommended for commercial cultivation (Khalil *et al.,* 2013). Finally, about 63 high yielding varieties (HYVs) have been released for cultivation in our country by

Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706
*Corresponding author: azizul@bsmrau.edu.bd.

the Tuber Crop Research Center of BARI of which Diamant, Cardinal, Granola, Patrones, Asterix, Lady Rosetta, Binnela, Multa, Provento, Heera, Dheera, Courage, Ailsa, Arinda, etc. are remarkable. Yield of these released varieties varies from 25 to 35 tone per hectare. Some of these varieties are late or some are early or medium late or medium early (Haque, 1993). Moreover, these varieties differ in various growth characters that largely influence the growing pattern, intercultural operations, and yield of a particular variety.

Research on potato cultivars is usually limited to analyzing differences in tuber yield, but has rarely done such analyses that account for the origins of such differences. For an optimal use of natural resources, an explanation for the production differences is important both for physiologists and agronomists (Borrego *et al*., 2000) in order to obtain useful information for the choice of genotype and the most appropriate agronomic practices to adopt. Indeed, potato cultivars show considerable diversity in terms of growth rates due to their genetic make-up and their interaction with the environment. Therefore, a study of dry matter production and accumulation in the various plant organs during development is important to determine a cultivar's growth rate and production. For this purpose, growth analysis has been widely used to study the factors that affect the plant's production and development as the accumulation of photosynthates in time (Ascione *et al.,* 2013). Moreover, potato plants are highly sensitive to unfavorable environmental condition (Dwelle and Love, 2014). Proper growth analysis of a potato variety ensures the yield by timely performing the intercultural operations and other activities.

Although, we have more than 60 potato varieties recommended for cultivation in Bangladesh, but a few of them are popular among the farmers. Therefore, detailed and organized growth analysis of varieties particularly dry matter accumulation pattern might be useful towards achieving high yield and finally, popularization of varieties to the farmers in a particular situation. But a little or no work has been done on growth analysis in our climatic condition.

Considering the above facts, the present study was undertaken to analyze the dry matter accumulation pattern in different organs of four potato varieties at different days after planting.

Materials and Methods

The experiment was conducted at the Horticultural Research Farm, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during the winter season of 2013-14. The experiment was laid out in the field following Randomized Complete Block Design with three replications. Four potato varieties viz., Asterix, Cardinal, Diamant, and Granola were considered as treatment and assigned randomly to plots. Apparently disease free, uniform sized (28-55 mm) well sprouted potatoes were selected as planting material for the experiment. Unit plot size was 4.8 m × 2.5 m, and tubers were planted following a spacing of 60 cm x 25 cm. Seed tubers were planted on 24 November 2013 and final harvesting was done on 22 February 2014. Recommended doses of fertilizers (Anon., 2012) was used in the trial. Cow dung was applied during final land preparation. Full dose of TSP, MP, Gypsum, $ZnSO_4$, Boric acid and half of Urea were applied in furrows at the time of planting

of tubers and then mixed in soil so that the tubers do not come in contact with fertilizers. The remaining half of Urea was applied as top dress at 30 days after planting (DAP). Irrigation, weeding, earthing up and other intercultural operations were done as and when necessary for raising a good crop. Furadan 5G @ 10 kg/ha was applied during the final land preparation to control cutworm and other soil borne insects. Malathion (0.2%) sprayed in two installments at 45 and 60 DAP to control insects. The crops were sprayed with Dithane M-45 (0.2%) alternatively five times (at 30, 40, 50, 60, and 70 DAP) to prevent late blight infection and other diseases of potato. Data on dry matter was estimated at different DAPs and tuber yield per plant was taken at harvest. Destructive sampling of plants was done at 10 days interval to determine dry matter accumulation. Five plants were harvested from each plot at 30, 40, 50, 60, 70, and 80 DAP. Total plant biomass was separated into leaves, stems, roots, and tubers. For dry matter estimation of each biomass group except tuber, total fresh weight was taken with an electric balance and kept in an oven. The temperature of the oven was set to 65° C and was dried up to a constant weight. The final weight of the dried sample was taken by an electric balance. Finally, dry matter (%) was calculated following the standard formulae. In case of tuber, about 100 g of fresh tuber was measured and dry weight was taken at 30, 40, 50, 60, 70, 80, and 90 DAP following the procedure described above. Besides, proportion of total dry matter partitioned to leaf/stem/root/tuber at each harvesting date was calculated using the following formula:

$$\text{Proportion of leaf/stem/root/tuber dry matter (\%)} = \frac{\text{leaf/stem/root/tuber dry wt.(g)}}{\text{Total dry wt. plant (g)}} \times 100$$

The collected data on various parameters were statistically analyzed using MSTAT-C program. The means were separated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

The accumulation of biomass to different components of a plant is an important consideration in achieving desirable yield (Saxena *et al.,* 1990). Data collected from the plots conducted in experimental field allowed to generate graphs for cumulative dry matter growth for each plant organ (stem, leaf , root, and tuber) as shown in Fig. 1 to 4. Dry matter at different plant components at different days after planting varied due to different genetic makeup of four potato varieties used in this experiment.

Stem dry matter (%)

Stem dry weight of four potato varieties was measured at 10 days interval starting from 30 DAP and continued up to 80 DAP under field condition. All the genotypes produced minimum stem dry weight at 30 DAP, which varied significantly (Fig. 1). Granola produced the highest dry matter (5.33%) and Asterix the lowest (4.54%). A gentle increasing pattern of dry matter accumulation for stem growth was observed from 30 to 70 DAP. At 40, 50, and 60 DAP, the stem dry matter was statistically similar in all four varieties. During 70 DAP, Granola produced the lowest dry mass (5.62%), but Asterix produced the highest (7.04%). All the varieties produced maximum stem dry weights at 80 DAP, but they did not vary significantly. However, Diamant stored the highest dry mass (10.69%) and Asterix the lowest (7.09%). Similar findings

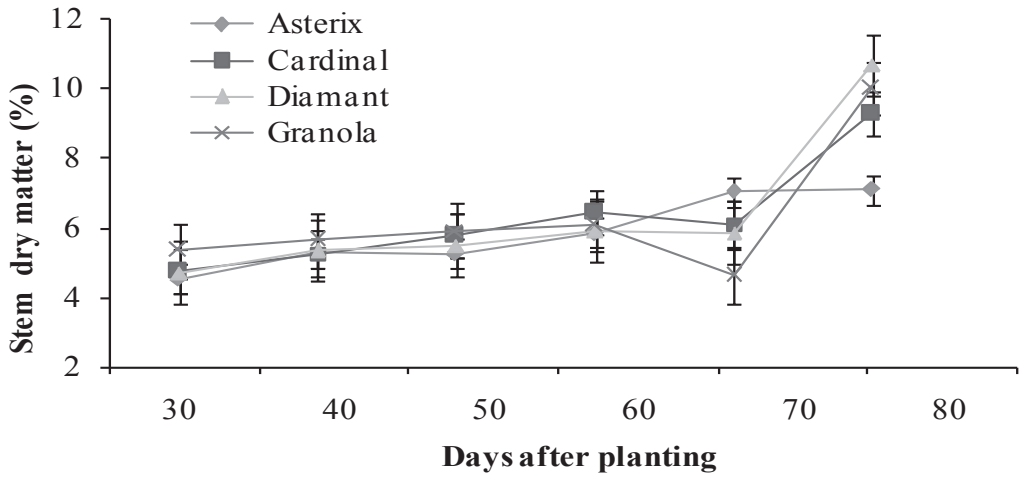

Fig. 1. Percent stem dry matter accumulation in four potato varieties at different days after planting.

in case of potato varieties were reported by Harahagazwel *et al.* (2012), who obtained gradual increasing trend in stem dry matter from 20 to 80 DAP.

Leaf dry matter (%)

Leaf dry weight is usually a good indicator of potential plant growth and yield. Leaf dry weight of four potato varieties was measured at 10 days interval starting from 30 DAP and continued up to 80 DAP under field condition. Asterix produced the highest leaf dry matter (9.11%) followed by Diamant (8.92%), Granola (8.63%), and Cardinal (5.74%) (Fig. 2). The dry mass allocation for leaf growth from 30 to 80 DAP followed an increasing pattern for all the four potato varieties. Again at 40 DAP, the highest assimilate was observed in Asterix (10.65%) and the lowest in Cardinal (9.68%). Leaf dry matter at 50, 60, 70, and 80 DAP in all four varieties did not vary significantly. Numerically, the highest value of assimilates in leaf attained at 80 DAP. However, at this stage, the highest value was found in Asterix (13.98%) and lowest in Cardinal (12.97%). It might be due to leaves played a vital role in growth, and they remained important from the beginning to the end of the crop growth cycle. Harahagazwe1 *et al.* (2012) obtained an increasing pattern in leaf dry matter content from 20 to 80 DAP in eight genotypes of potato. As indicated by Tourneux *et al.* (2003), tuber growth and development depend on the presence of sufficient foliage to produce the necessary assimilates. According to Geremew *et al*. (2008), leaf biomass production is proportional to the fraction of solar radiation intercepted which influence photosynthetic production and tuber yield finally.

Root dry matter (%)

Root dry weight of four potato varieties were measured at 10 days interval starting from 30 DAP to 80 DAP under field condition. During 50 DAP, the highest value was obtained in Granola (15.04%) and the lowest (12.02%) in Asterix (Fig. 3). At 60 DAP, the highest

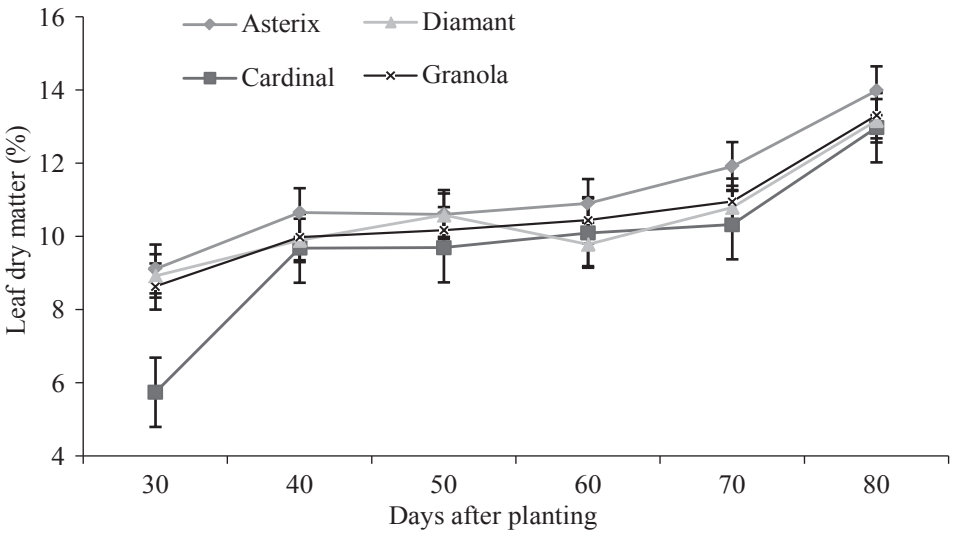

Fig. 2. Percent leaf dry matter accumulation in four potato varieties at different days after planting.

dry mass stored in Cardinal (14.80%) and the lowest in Diamant (11.23%). The highest value of root dry matter was recorded in Granola (17.96%) and the lowest in Asterix (14.44%) at 70 DAP. Asterix and Cardinal attained the maximum root dry mass at 80 DAP. But in case of Diamant and Granola, it was maximum at 70 DAP and decreased at 80 DAP. The dry matter accumulation pattern in root was observed more or less static up to 60 DAP in all the studied varieties. Similar findings were reported by Mahmud (2012) and Timlin *et al.* (2006), who stated that root dry matter remained static throughout the growth season. If the root development is disturbed, plant growth and health might be clearly reduced (Lottmann *et al.,* 1999). One of the physiological concepts is that gaining accepted root dry weight is important for avoiding stress and maintaining healthy vigorous growth of plant, which is conducive to maximum yield (Hake *et al*., 1990). As indicated by Tourneux *et al.* (2003), tuber growth and development are dependent on the presence of sufficient roots for adequate supply of water and nutrients to the canopy.

Tuber dry matter (%)

Dry matter accumulation in tuber was measured at 10 days interval starting from 30 to 80 DAP under field condition. Dry matter of tuber at different growth stages varied in four potato varieties. All the varieties produced minimum assimilates at 30 DAP. This might be due to earlier stage of tuber initiation for all the varieties. All the plants were at vegetative stage so distributed very minute proportion of produced assimilates to tubers. The data reveals that the trend of dry matter allocation for tuber growth followed an increasing pattern. At 40 DAP, the highest assimilate value was found in Cardinal (15.21%) and the lowest (12.88%) in Granola (Fig. 4). At 50 DAP, dry matter of tubers in all the varieties was statistically similar. However, the highest value was attained by Cardinal (15.78%) and the lowest by Granola (13.27%). The Highest

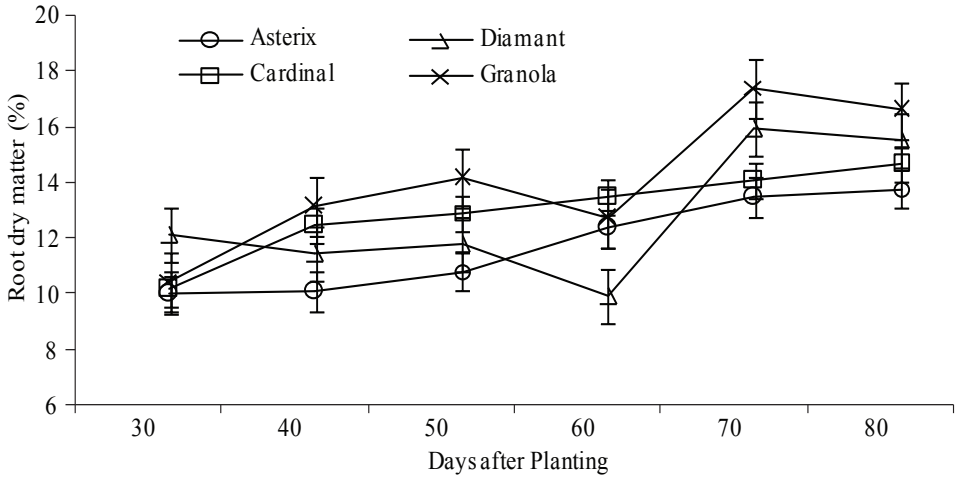

Fig. 3. Percent root dry matter accumulation in four potato varieties at different days after planting.

and the lowest dry mass was obtained by Cardinal (16.73%) and Granola (14.04%), respectively, at 60 DAP. Similar result was recorded in 70 DAP, the highest value in Cardinal (19.60%) and the lowest in Granola (15.80%). But during 80 DAP (near harvest time), the highest tuber dry matter content was found in Diamant (20.71%) and the lowest in Granola (17.84%). Dry matter accumulation in tubers increased rapidly in all the studied varieties from 30 to 80 DAP. Similar findings were reported by Harahagazwe1 *et al.* (2012) and Timlin *et al.* (2006). They obtained the highest tuber dry matter content at 80 DAP. But Pelletier and Fry (1990) and Begum *et al.* (2011) obtained the highest dry matter at 90 DAP. According to the findings of Kooman and Rabbinge (1996), the model calculations of the fraction of total dry matter produced allocated to the tuber were on the basis of assumption that the tubers had been the dominant sink in the potato crop. Three phases of dominance of the tubers can be distinguished as the initial phase when tuber is limited sink, the second phase when there is competition for assimilates between tubers and other organs, and the third phase when tubers are such a strong sink that all assimilates are allocated to them.

Proportion of dry matter accumulation in different parts of potato plants at different days after planting

Initially after the final emergence (at 30 DAP), the highest dry matter was accumulated to leaves than that of tubers, and this trend was continued up to around 48 DAP (Fig. 5). This indicated that the cultivars were mainly partitioning dry matters to the canopy for vegetative development. At 50 DAP, this trend was changed and the highest dry matter accumulation was found in tuber followed by that in leaf, stem, and roots. This indicated that after 50 days of planting, potato plants were already at the end of the vegetative growth stage and in transition to the tuber filling stage. This was in agreement with the findings of Kooman *et al*. (1996), where they found that in the second phase, which starts after tuber set, an ever-increasing quantity

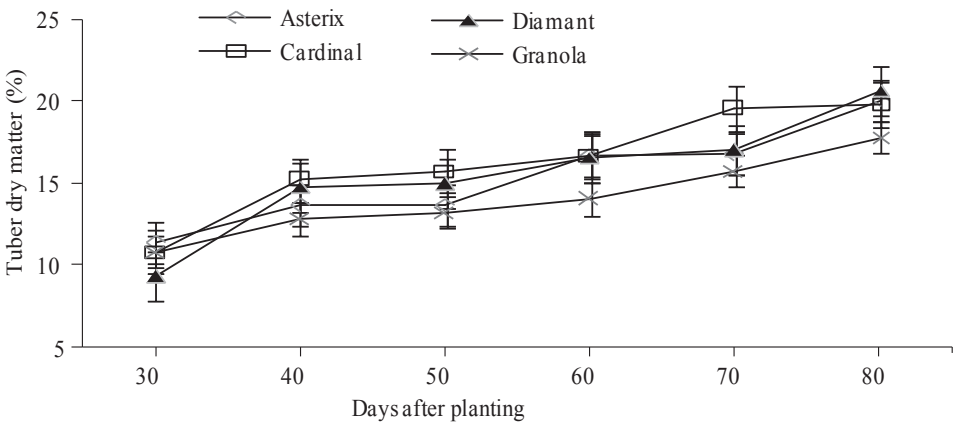

Fig. 4. Percent tuber dry matter accumulation in four potato varieties at different days after planting.

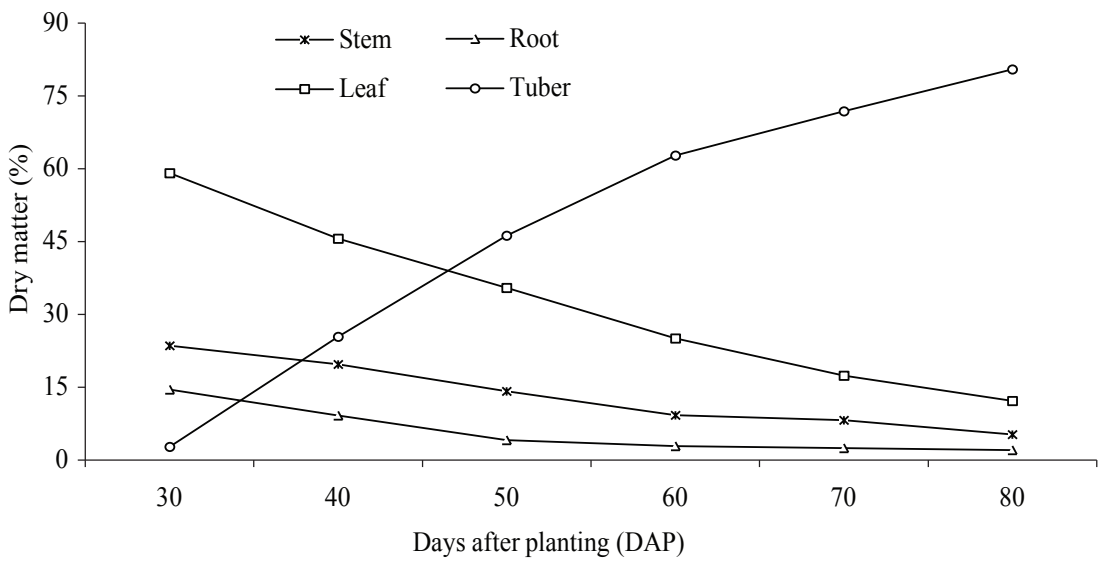

Fig. 5. Proportion of dry matter in different parts of potato plants at different days after planting.

of dry matter is allocated to the tuber and a decreasing fraction to the leaves and stem of potato. Geremew *et al.* (2007) recorded the highest dry matter accumulation to potato leaves at first harvest (58 DAP), and to tubers in the successive harvests (72, 84, and 101 DAP). Rate of dry matter accumulation to tubers from 30 DAP to 60 DAP increased linearly and after that increased steadily, but dry matter accumulation was the highest to tubers till 80 DAP. This indicated that potato plant was still diverting the major quantity of assimilates to the tubers, and tubers were the major sink at that period. Therefore, proper care should be taken to the potato crop at 30-60 DAP to have a healthy crop, which is essential for obtaining a good yield. Any sorts of stress in this period may reduce the yield. Reduction in yield from water deficit, deficiency of nitrogen, high temperature at

tuber bulking stage has also been reported in a publication of IBSNAT (1993). Singh *et al.* (2008) also observed a linear rate of dry matter accumulation to tubers up to 30 days after initiation (tuber initiated at 28 DAP), which corroborated the present findings. At 80 DAP, 80.5% assimilates were accumulated to the tubers. Victorio *et al.* (1986) reported to have 73 to 85% dry matter partitioned to tubers at mature harvest in the Sierra (150 DAP), but 33 to 75% on the Coast (120 DAP) in nine cultivars of potato. Whereas, Silva and Pinto (2005) reported to have 64.1%, 77.3%, 85.7%, and 89.4% dry matter partitioned to tubers at 58, 83, 108, and 133 DAP, respectively, in 23 potato genotypes in Brazil. These differences might be due to the variation in crop duration, growing environment, and interaction of cultivars to environment. Praharaj *et al.* (2010) reported that the partitioning of dry matter led to an almost exponential increase in the case of tubers soon after initiation or decrease in the case of leaves and stems in the early stages after emergence and thereafter, the rate of increase or decrease in allocation was marginal. The decrease in allocation to the leaves and stems is made up by the allocation to the tubers. This type of allocation is logical because in the case of determinate varieties, as the haulms approaches senescence stage, allocation to it decreases, and most of the dry matter produced goes to the tubers, which is realistic at this instant as all the varieties in our country are determinate type.

Fresh tuber yield at 90 DAP

The results pertaining to yield tone per hectare of different potato varieties are presented in Table 1. Yield of the four potato varieties varied significantly. The highest yield was found in Asterix (31.46t/ha), which was statistically identical to that of Diamant and Cardinal; whereas, Granola showed the lowest (24.82t/ha). Hoque *et al.* (2010) reported that yields of Asterix, Cardinal, Diamant, and Granola were 25-35 tone per hectare, 25-40 tone per hectare, 25-40 tone per hectare, and 20-30 tone per hectare, respectively. The highest tuber yield per plant was obtained from Asterix (472.00g). The present findings are in agreement with Mahmud (2012), who also found the highest yield per plant (368.97g) in Asterix. The variations in yield (t/ha) may be due to genetics, season, vegetative growth, disease incidence, crop duration/maturity, and adaptability to prevailing environment. Yield was significantly influenced by variety and season of production (Sinha *et al*., 1992). Gupta *et al.* (2009) also confirmed that there were significant effects of the season on total tuber yield, which might be due to different responses to genotypes to environmental conditions. Patel *et al.* (2008) provided that higher tuber yield might be due to better plant growth, genotype, adaptability in wide range of environment and combined effect of all other growth and yield attributes. Shah *et al*. (2007) exposed that in potato genotypes, the difference in tuber yield was primarily due to genetic factors. Another reason of higher yield might be their resistance to late blight.

Dry matter (%)

The highest (21.53%) dry matter content was found in Asterix during harvest and the lowest (18.92%) in Granola (Table 1). According to Hoque *et al.* (2010), Asterix showed 19% and Granola showed 19.1% dry matter during harvest.

Dry yield of tubers (t/ha)

The highest tuber dry weight per plant was in Asterix (101.67 g) and the lowest in Granola

Table 1. Tuber yield of four potato varieties during harvest (90 DAP)

Variety	Fresh yield of tuber		Dry matter at harvest (%)	Dry yield of tuber	
	g/plant	t/ha		g/plant	t/ha
Asterix	472.00 a	31.46 a	21.53	101.62 a	6.77 a
Cardinal	409.00 a	27.27 a	20.90	85.48 a	5.70 a
Diamant	448.67 a	29.91 a	21.40	96.02 a	6.40 a
Granola	372.67 b	24.82 b	18.92	70.51 b	4.70 b
Mean	425.58	28.37	20.56	88.17	5.88
CV(%)	20.85	20.84	14.32	13.66	13.64
$LSD_{0.05}$	78.45	5.23	NS	25.74	1.98

In a column, means followed by same letter(s) are not statistically different at 5% level by DMRT

(70.51 g) (Table 1). Barghi *et al.* (2012) reported that Agria and Satina varieties obtained tuber dry weight of 95.0 g and 90.0 g per plant, respectively. From this result, it was evident that the highest dry tuber yield was found in Asterix (6.77 tons per hectare) and lowest in Granola (4.70 tons per hectare). This finding was in agreement with the findings of Harahagazwe *et al.* (2012), who reported to have 5.7-6.8 tons per hectare dry yield of tubers in eight CIP potato genotypes.

Conclusion

Dry matter accumulation in stem and leaves increased gradual, while in root, it showed a static pattern throughout the growing season. But in case of tuber, dry matter accumulation from 30 to 60 DAP increased linearly and after that increased steadily. Dry matter accumulation in tuber was found the highest in Asterix (21.53%) and the lowest in Granola (18.92%) during harvest at 90 DAP. At early growth stages (up to 48 DAP), maximum dry matter was partitioned to leaves; but after that, maximum dry matter started to be partitioned to tubers in all the varieties of potato plant.

References

Ali, M. S. and A. Haque. 2011. Potato for food security in SAARC countries; SAARC Seed Congress & Fair 2011, Dhaka, Bangladesh.

Anonymous. 2012. Annual report of TCRC 2011-12. Tuber Crops Research Center, Bangladesh Agricultural Research Institute, Gazipur 1701, Bangladesh.

Anonymous. 2014. Estimates of potato, 2012-2013. Agriculture Wing, Bangladesh Bureau of Statistics, Government of the People's Republic of Bangladesh, Agargaon, Dhaka 1207, Bangladesh.

Ascione, S., C. Ruggiero and C. Vitale. 2013. Contribution of growth components on relative, plant, crop, and tuber growth rate of nine potato cultivars in southern Italy. *Intl. J. Sci*. 2: 1-11.

Barghi, A., A. Tobeh and N. Hassanzadeh. 2012. Effect of nitrogen fertilizer levels on tuber filling rate and protein assimilation in early and late maturing potato. *Annals Biol. Res.* 3(9): 4264-4275.

Begum, F., B. C. Kundu, M. I. Hossain, S. Akter and M. M. Hossain. 2011. Physiological analysis of growth and yield of potato in relation to planting date. Annual Report 2010-11, Tuber Crops Research Center, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh. Pp. 139-143.

Borrego, F., J. M. Fernández, A. López, V. M. Parga, M. Murillo and A. Carvajal. 2000. Growth analysis in seven varieties of potato (*Solanum tuberosum* L.). *Agronomía Mesoamericana* 11(1): 145-149.

Dwelle, R. B. and S. L. Love. 2014. Potato growth and development. Available at: http://www.cals.uidaho.edu/potatoes/PotatoProductionSystems/Topics/ Growth%26Development.pdf. [Accessed on 06/10/2014].

Geremew, E. B., J. M. Steyn and J. G. Annandale. 2007. Evaluation of growth performance and dry matter partitioning of four processes potato (*Solanum tuberosum.* L.) cultivars. *New Zealand J. Crop Hort. Sci*. 35(3): 385-393.

Geremew, E. B., J. M. Steyn and J. G. Annandale. 2008. Comparison between traditional and scientific irrigation scheduling practices for furrow irrigated potatoes (*Solanum tuberosum* L.) in Ethiopia. *South African J. Plant Soil*. 25(1): 42-48.

Gomez, K. A. and A. A. Gomez. 1984. Statistical procedure for agricultural research. John N. Y, Wily and Sons, Pp. 20-215.

Gupta, V. K., B. K. Das and S. K. Pandey. 2009. Performance of local potato varieties in Meghalaya Hills. *Potato J.* 36(1-2): 65-67.

Hake, K., K. Cassman, F. Whisler and D. Upchurch. 1990. Root physiology and management. *Physiology Today Newsletter* 4 P.

Haque, M. A., M. A. M. Miah, S. Hossain, and M. M. Rahman. 2012. Profitability of BARI released potato (*Solanum tuberosum* L.) varieties in some selected locations of Bangladesh. *Bangladesh J. Agric. Res.* 37(1): 149-158.

Harahagazwe1, D., J. F. Ledent and G. Rusuku. 2012. Growth analysis and modelling of CIP potato genotypes for their characterization in two contrasting environments of Burundi. *African J. Agric. Res*. 7(46): 6173-6185.

Hoque, M. A. 1993. Evaluation of exotic potato varieties in 2nd generation. Annual Report 1992-93. Tuber Crops Research Center, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh. Pp.1-7.

Hoque, M. A., S. Abdullah, M. Hossain and M. A. J. Bhuiyan. 2010. Processing characteristics of different potato varieties (*In Bengali*). Tuber Crops Research Sub Center, BARI, Munshiganj and KGF, Dhaka. Pp. 1-16.

IBSNAT. 1993. Research Report Series 02. A simulation model for potato growth and development: SUBSTOR- Potato version 2.0. Dept. of Agronomy and Soil Science, College of Tropical Agriculture and Human Resources, Univ. of Hawaii, Honolulu, HI.

Khalil, M. I., M. E. Haque and M. Z. Hoque. 2013. Adoption of BARI recommended potato (*Solanum tuberosum* L.) varieties by the potato farmers of Bangladesh. *The Agriculturist* 11(2): 79-86.

Kooman, P. L. & R. Rabbinge. 1996. An analysis of the relation between dry matter allocation to the tuber and earliness of a potato crop. *Annals Bot*. 77: 235-242.

Kooman, P. L., M. P. Fahem, P. Tegera and A. J. Haverkort. 1996. Effect of climate on different potato genotypes 2. Dry matter allocation and duration of the growth cycle. *European J. Agron*. 5: 207-217.

Lottmann, J., H. Heuer, K. Smalla and G. Berg. 1999. Influence of transgenic T4-lysozyme-producing potato plants on potentially beneficial plant-associated bacteria. FEMS *Microbiol. Ecol*. 29: 365-377.

Mahmud, A. A. 2012. Improvement of drought tolerant potato varieties-An unpublished Ph. D. Dissertation. Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricutural University, Salna, Gazipur.

Miah, M. A., M. S. Hossain, T. M. B. Hossain and S. Rahman. 2011. Assessment of potato farmers' perceptions on abiotic stresses and implications for potato improvement research in Bangladesh: A baseline survey. Research report submitted to International Potato Center (CIP), Lima, Peru.

Patel, C. K., P. T. Patel and S. M. Chaudhari. 2008. Effect of physiological age and seed size on seed production of potato in North Gujarat. *J. Indian Potato Assoc*. 27(3-4): 87-90.

Pelletier, J. R. and W. E. Fry. 1990. Characterization of resistance to early blight in three potato cultivars: Receptivity. *Phytopathol*. 80: 361-366.

Praharaj, C. S., P. M. Govindakrishnan and S. S. Lal. 2010. Dry matter distribution in potato genotypes as affected by physiological degree days. *Potato J.* 37(3- 4): 138-142.

Saxena, C. M., S. N. Silim and B. K. Sing. 1990. Effect of supplementary irrigation during reproductive growth on winter and spring chickpea (*Cicer arietinum*) in a Mediterranean environment. *J. Agric. Sci*. 114: 285-293.

Shah, U. P., S. Kumar, N. P. Singh, A. K. Chaubey and Y. Kumar. 2007. Potato varietal discrimination using ground based multiband radiometer. *J. Indian Soc. Remote.* 35: 53-65.

Silva, L. A. S. and C. A. B. P. Pinto. 2005. Duration of the growth cycle and the yield potential of potato genotypes. *Crop Breed. Appli. Biotech.* 5: 20-28.

Singh, R. K., J. P. Singh and S. S. Lal. 2008. Dry matter partitioning relative to development in high yielding Indian potato cultivars under short day tropical conditions. *Potato J.* 35(3- 4): 161-166.

Sinha, N. K., J. N. Cash and R. W. Chase. 1992. Differences in sugars chip color, specific gravity and yield of selected potato cultivars grown in Michigan. *Amer. Potato J*. 69: 385-389.

Timlin, D., S. M. L. Rahman, J. Baker, V.R. Reddy, D. Fleisher and B. Quebedeaux. 2006. Whole plant photosynthesis, development, and carbon partitioning in potato as a function of temperature. *Agron. J.* 98: 1195–1203.

Tourneux, C., A. Devaux, M. Camacho, P. Mamani and J. F. Ledent. 2003. Effect of water shortage on six potato genotypes in the highlands of Bolivia (I): morphological parameters, growth and yield. *Agronomi.* 23: 169-179.

Victorio, R. G., U. Moreno and C. C. Black. 1986. Growth, partitioning and harvest index of tuber-bearing *Solanum* genotypes grown in two contrasting Peruvian environments. *Plant Physiol.* 82: 103-108.