OPEN ACCESS Journal of Agronomy

ISSN 1812-5379
DOI: 10.3923/ja.2018.

Research Article
Agronomic Characteristics of Several Local Varieties of Potato Cultivated in a Protected Area

Anna Rita Rivelli and Susanna De Maria

School of Agricultural, Forest, Food and Environmental Sciences, University of Basilicata, Potenza, Italy

Abstract

Background and Objectives: Potato, the number one non-grain food commodity in the word, has recently been the subject of numerous research projects aimed at recovering endemic or local genotypes, especially in the original countries. In view of the worldwide interest on local germplasm conservation, the aim of the study was to evaluate the agronomic performances and tuber characteristics of several local potato varieties, which are still cultivated in small towns in the Pollino National Park. **Materials and Methods:** The experiment was carried out at the "Pollino" Experimental Agricultural Farm Station, located in Rotonda (Potenza, Italy). Eight local potato varieties were compared with three commercial varieties. Number of leaves and inflorescences and plant height were measured during the growing cycle. While, number of tubers per plant, weight and size were recorded at the harvest and analyzed by one-way ANOVA. **Results:** Data of yield, number and average unit weight of the tubers were statistically different among varieties. Except for the commercial variety (Spunta), that showed scarce vegetative development and resulted unproductive, the yield of tubers ranged from 170-700 g/plant, with two local varieties (Rossa and Bianca di Terranova) and the commercial variety (Marabel) being the most productive (640 and 510 g/plant, respectively). The majority of the local varieties produced tubers with irregular shapes, which were mainly small in some varieties and medium-large in the others. **Conclusion:** Results suggest that it would be worthwhile to focus on agronomic studies in order to improve production facilitating local biodiversity conservation and in the meantime avoiding land abandonment.

Key words: Biodiversity, growth performances, local varieties, plant development, *Solanum tuberosum*

Received: Accepted: Published:

Citation: Anna Rita Rivelli and Susanna De Maria, 2018. Agronomic characteristics of several local varieties of potato cultivated in a protected area. J. Agron., CC: CC-CC.

Corresponding Author: Susanna De Maria, School of Agricultural, Forest, Food and Environmental Sciences, University of Basilicata, Via dell'Ateneo Lucano 10, 85100 Potenza, Italy Tel: (+39) 0971 205382 Fax: (+39) 0971205378

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Cultivated potato (*Solanum tuberosum* L.) is the number one non-grain food commodity in the world, the fourth most important food crop after wheat, maize and rice, with a global annual production exceeding 350 million tonnes[1]. Considering the worldwide consumption and diffusion of potatoes[2], as well as its nutritional value and peculiar features[3-5], the United Nations General Assembly declared 2008 as the International Year of the Potato (IYP). This event aimed to raise the awareness of the fundamental importance of potatoes as a staple food for humanity and to focus the world's attention on the recovery and preservation of new varieties drawn from the potato gene pool in order to improve the yield and nutritional value, to combat pests and diseases and to sustain production of marginal lands[6]. In this context, the species, which has long been studied in various fields of research, from the agronomic to the pharmaceutical and industrial sectors[7-9], has recently been the subject of numerous research projects aimed at recovering endemic or local genotypes, especially in the original countries[10,11]. Indeed, considering the risks resulting from genetic erosion of agricultural plant resources, several research projects have been addressing the safeguarding and conservation of crop biodiversity[12,13], by surveying, preserving and promoting the agro-biodiversity, particularly in protected areas for their role as repositories of wilderness. Therefore, detailed research studies were carried out to analyse quantitative and qualitative characteristics of different potato ecotypes in a number of areas[14,15].

In the Pollino National Park (PNP) (the largest protected area in Italy), recent studies highlighted the richness of the genetic resources of agricultural interest (local genotypes and ancient varieties of a number of species)[16,17], besides emphasizing the spectacular biological diversity and the ecological role for biodiversity conservation. Numerous ancient fruit varieties, ecotypes of cereals, legumes and horticultural crops (several of which are included in the list of typical products certified PDO and PGI or Slow Food Presidia, or officially approved as Traditional Food Products named PAT) have been inventoried in municipalities inside the park. Particularly, as a result of a research survey funded by the park Authority from 2008, 500 varieties of fruit trees (belonging to 41 species) and 176 varieties of cereals and horticultural crops (belonging to 53 species) have been counted[18,19]. Among the horticultural crops, the promotion of traditional and local varieties or ecotypes of potato, still cultivated in small areas of several municipalities of the park area are under way. Some of them, such as Patata Rossa di Terranova di Pollino, are included in the PAT list, while other varieties, which come from the municipality of San Severino Lucano, are even at risk of extinction, being cultivated exclusively by "Custodian" farmers that jealously preserved them over the years. In this context, the aim of the study was to evaluate plant development and agronomic performances of eight local potato varieties cultivated in small areas of the PNP compared with three commercial varieties also cultivated in mountainous areas, with similar pedo-climatic conditions as the PNP. The experiment was conducted within the activities of research undertaken by the park authority aimed at promoting agro-food and rural development of the park.

MATERIALS AND METHODS

Plant material and designs: The experiment was carried out on eleven varieties of *Solanum tuberosum* grown in an open field in 2011 at the "Pollino" Experimental Agricultural Farm Station, located in Rotonda (Potenza, Italyn coordinates: 39°57 07"N, 16°02 20"E; 580 m a.s.l.) the head office of the Managing Authority of the Pollino National Park.

Eight local varieties of potato (Paesana Gialla, Paesana Bianca, Casale, Marca, Patata Rossa di Terranova di Pollino, Patata Bianca di Terranova di Pollino, Patata Rossa di Teana, Patata Bianca di Teana) were compared with three commercial varieties (Marabel, Desiree and Spunta). The tubers used for sowing the local varieties were recovered from farmers of the park area who still retained these ancient local varieties and the tubers of the commercial varieties were purchased from local suppliers. More details about the geographical origin (town, altitude and geographic coordinates) of the propagation material used are reported in Table 1. After having ploughed the soil, the seed tubers of the eleven varieties were manually planted at a depth of about 10-15 cm in single rows (80 cm between the rows and 35 cm on the row) in plots (3.20×20 m) replicated three times, by the end of May, 2011. The agronomic practices (fertilization, irrigation, plant protection and weed control) were carried out following the disciplinary regulations for the production of potatoes in force in the park area and the local customs and practices.

Data collection: For the eleven varieties of potato selected for this study, data on plant development and quantitative and qualitative parameters of the tubers were recorded on 6 plants per plot. During the growing cycle, approximately every 10 days, the plant height (cm), number of leaves and inflorescences were measured. By the end of September, plants were harvested and the number of tubers per plant, weight (balance mod. SVI-50C, Acculab Sartorius, Goettingen, Germany) and size (caliber mod. 53301, Turoni s.r.l. Forlì, Italy)

Table 1: Name, type and geographical origin (town, altitude and geographic coordinates) of the eleven varieties of potato analyzed

Name of the variety	Type	Town of provenance	Altitude (m a.s.l.)	Latitude	Longitude
Paesana Gialla	Local	San Severino Lucano	897	40°01 12" N	16°08 18" E
Paesana Bianca	Local	San Severino Lucano	"	"	"
Casale	Local	San Severino Lucano	"	"	"
Marca	Local	San Severino Lucano	"	"	"
Patata Rossa di Terranova di Pollino	Local	Terranova di Pollino	863	39°58 39" N	16°17 44" E
Patata Bianca di Terranova di Pollino	Local	Terranova di Pollino	"	"	"
Rossa di Teana	Local	Teana	781	40°07 33" N	16°09 10" E
Bianca di Teana	Local	Teana	"	"	"
Marabel	Commercial	-	-	-	-
Desiree	Commercial	-	-	-	-
Spunta	Commercial	-	-	-	-

were recorded. This latter was defined by subdividing the tubers according to their weight (small tubers from 2-70 g and large above 71 g) and diameter (<40, 41-60 and >61 mm) in size classes and expressed as a percentage. Qualitative parameters including skin color, pulp color, tuber shape, color and depth of the eyes were also recorded.

Statistical analysis: Data were analyzed with one-way analysis of variance (ANOVA) to evaluate the significant differences among the potato varieties compared and means were separated by the Duncan's test at 0.05 probability level.

RESULTS AND DISCUSSION

Plant development during the growing cycle: Plant height and leaf number of the eleven varieties of potato analysed were recorded throughout the growing cycle (Fig. 1a, b, respectively). Considering plant height (Fig. 1a), differences among the varieties were already visible about one month after planting and maintained until harvesting plants: Rossa di Terranova and Desiree (local and commercial varieties, respectively) were the tallest varieties (with about 17.5 cm 34 days after planting up to 88 cm at harvest). Intermediate values were recorded in the other seven local varieties followed by the commercial Marabel and Spunta varieties that showed the lowest values (from 5-54 cm, on average). Considering the number of leaves per plant (Fig. 1b), the varieties in comparison had an upward trend during plant development until 87 days after planting when the highest number of leaves were recorded, then kept more or less constant or tendentially descending with the approaching of plant senescence. As for plant height, the number of leaves was higher in the varieties coming from the town of Terranova di Pollino (Rossa and Bianca) and the commercial variety Desiree, followed by Bianca di Teana, Paesana Bianca, Paesana Gialla and Casale. The lowest foliage was recorded in Spunta. Overall, values ranged from 2-6 leaves after 34 days of planting and from 13-21 leaves close to the harvesting of the tubers.

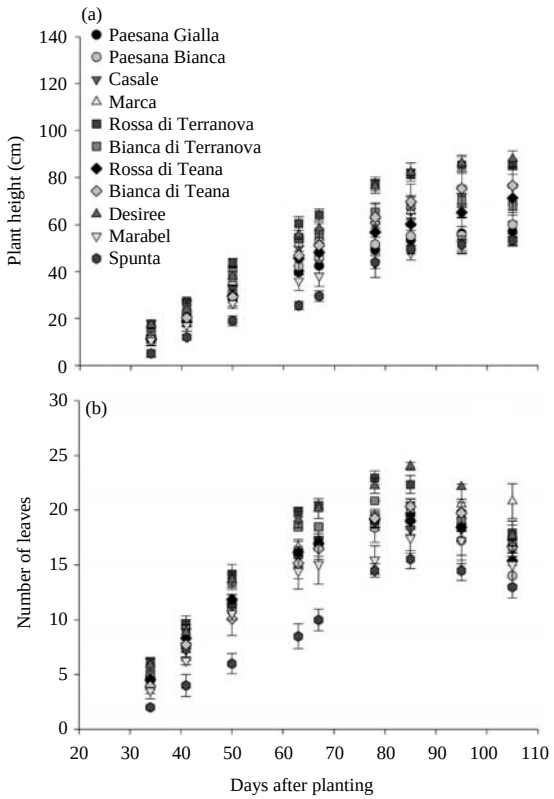

Fig. 1(a-b): (a) Plant height and (b) Number of leaves during the growing cycle of the eleven varieties of potato analyzed. Values are means (n = 6) ± SE

Differences in terms of plant height and number of leaves among the varieties analysed were expected as found in several studies regarding the evaluation of agronomic performances of potatoes[9,15]. According to several authors, such differences were associated to genetic variability, length and number of internodes on the stem[20,21], leaf morphology[15] and growing conditions (e.g., temperature, altitude)[22]. In this case, differences in plant development of the commercial varieties (particularly Spunta) could be associated to the adaptability to the pedo-climatic conditions of the park area.

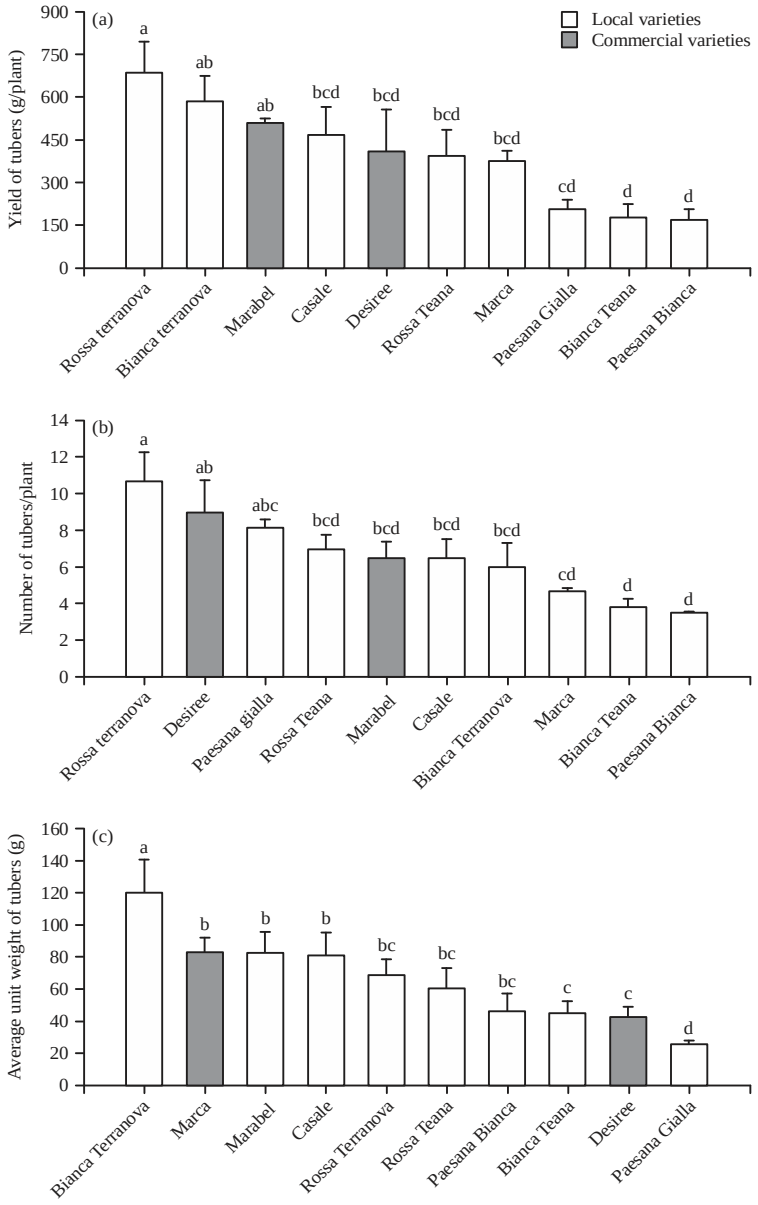

Fig. 2(a-c): (a) Yield, (b) Number and (c) Average unit weight of the tubers of the potato varieties analysed. Values are means (n = 6) ± SE. Different letters above the bars indicate significant differences for $p \leq 0.05$ based on Duncan's test

In fact, considering flowering duration and number of inflorescences, the local varieties showed a similar trend with the exception of Rossa di Terranova that produced more inflorescences (up to 4-5, two months after planting), while among the commercial varieties, Spunta and Marabel showed a shorter flowering duration and flowered later than Desiree (data not shown).

Tuber traits and yield: Data of yield, number and average unit weight of the tubers were statistically different among the varieties analyzed (Fig. 2). Except for the commercial variety Spunta, that showed lowered vegetative development and resulted unproductive, the yield of tubers ranged from 170-700 g/plant, with average values of 384 and 460 g/plant for local and commercial varieties, respectively (Fig. 2a). The two local varieties Rossa and Bianca di Terranova and the commercial Marabel showed the highest yields of tubers while Bianca di Teana, Paesana Bianca and Gialla the lowest (184 g/plant, on average), intermediate values were recorded in the remaining varieties (414 g/plant, on average). It is well known that potato yields vary depending on several factors, including crop varieties and genotypes[23]. The yield per hectare

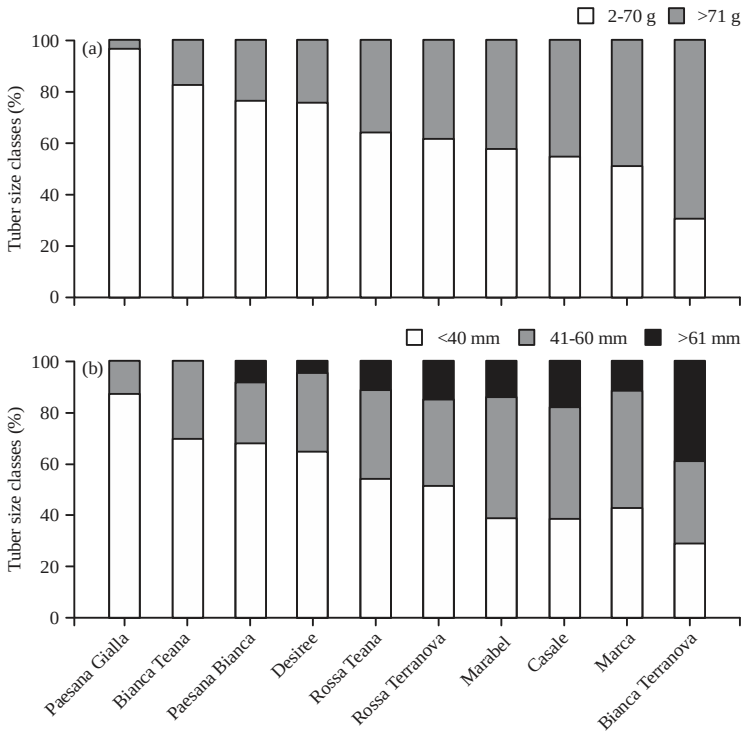

Fig. 3(a-b): Tuber size classes (expressed as percentage) based on (a) Weight and (b) Diameter of the tubers

ranged from about 4-17 t, with Rossa and Bianca di Terranova showing the highest production. These latter, together with the commercial variety Marabel, were the only ones showing a tuber production falling within the typical potato production range of Central European countries (ranging between 12 and 20 t ha^{-1}) according to Pedersen *et al.*[24]. In Italy the potato production is reported to vary from 22.4-25.9 t ha^{-1}, but unfortunately it is difficult to estimate and identify a mean yield because of the co-existence of a myriad of potatoes types and varieties[24]. Particularly, the same authors indicated that for commercial potato production the average is higher at about 40 t ha^{-1} [24]. Therefore, the choice of variety plays a significant role in potato production, mainly in regions with small production areas and with pedo-climatic conditions that do not favour the cultivation of commercial cultivars.

Besides the production, the number of tubers produced per plant has also been taken into account, as shown in Fig. 2b. The potato Rossa di Terranova and the commercial variety Desiree showed the highest values (11 and 9, respectively) while Bianca di Teana and Paesana Bianca the lowest (3.6 on average), the remaining varieties produced between 6 and 8 tubers. Although Rossa di Terranova was the most productive, it showed an average unit weight of tubers much lower than Bianca di Terranova which reached the highest absolute weight (120 g) as reported in Fig. 2c, in contrast, the significantly lower values were presented by Paesana Gialla (25 g) and Bianca di Teana (45 g). The other local varieties like Casale, Marca, Rossa di Terranova, Rossa di Teana and Paesana Bianca and the commercial variety Marabel produced tubers of intermediate weight, which resulted not statistically different among themselves. In order to better distinguish the differences between the varieties, the number of tubers was expressed as a percentage by separating small (weighing between 2 and 70 g) and big tubers (weighing more than 71 g) according to their respective weight (Fig. 3a). Among the local varieties, Paesana Gialla produced many small tubers accounting for 96% of the total production, followed by Bianca di Teana (82%), Paesana Bianca (76%) and finally Marca and Casale that both showed 50% of the two weighted classes considered. Conversely, Bianca di Terranova produced a few small tubers and a high percentage of big tubers (70%). Even the two commercial varieties produced rather big tubers than small. As regards to the size of the tubers, classified according to their diameter (small <40 mm, medium 41-60 mm, large > 61 mm) (Fig. 3b), the majority of the varieties produced homogeneous tubers mostly comprised between the small and medium sized classes, Paesana Gialla, Paesana Bianca and Bianca di Teana showed a high percentage of small-sized tubers (up to 70%) while Bianca di Terranova showed mainly medium to large

Table 2: Tuber characteristics of the local (the first eight in the table) and commercial (the last two) varieties of potato analyzed

Variety	Shape	Depth of eyes	Skin color	Pulp color
Paesana Gialla	Oval round	Deep	Yellow	Yellow
Paesana Bianca	Oval Round	Shallow	Yellow	White
Casale	Round	Shallow	Dark yellow	White
Marca	Oval round	Medium	Dark yellow	White
Rossa di Terranova	Long oval	Shallow	Red	Yellow
Bianca di Terranova	Long oval	Shallow	Yellow	White
Rossa di Teana	Oval	Deep	Red	White
Bianca di Teana	Long oval	Shallow	Dark yellow	White
Marabel	Oval	Medium	Yellow	Dark yellow
Desiree	Oval	Shallow	Red	Light yellow

sized tubers. Potato and other vegetable crops are commonly priced differently across a range of product sizes. Tuber size is an indicator of the "marketable yield" which is more important than the total tuber yield. The usable portion is related to the average weight of potatoes. The smaller the potatoes, the greater the proportions discarded by peeling[7]. Generally, production goals require optimizing tuber size to maximize crop value, since different potato market classes have different pay scales across different tuber size categories. In our case, even considering the sizes, the best local varieties showed best performances in comparison with the best commercial varieties. Such results were almost expected during the supervision of plant development, considering that the growth of the tubers is related to morphometric parameters of the above-ground portion[23,25]. However, considering that tuber size is correlated with number of stems per plant and plant density[25,26], further studies should be addressed to evaluate the best agronomic practices to improve local variety production. In this context, local testing of endemic and commercial potatoes is necessary, since the growth and development is considerably influenced also by climatic and soil conditions.

Besides quantitative agronomic performances, including size, potato tubers come in thousands of varieties with great differences in shape, colour, texture and taste, which affect cooking characteristics and differently attract the interest of the consumers. Therefore, at harvesting time some tuber traits have been noted, as shown in Table 2. Among the local varieties, almost all presented light to dark yellow skin with the exception of Rossa di Terranova and Rossa di Teana, which as indicated by their names have both red skin. Paesana Gialla and Rossa di Terranova were the only type with yellow pulp. Tubers were mostly oval shaped or long and round oval, many of them presented shallow, yellow or white-colored eyes. Considering the two commercial varieties, Marabel presented both yellow skin and pulp while Desiree was red skin and light yellow pulp. Both varieties produced long oval tubers, of medium-size with yellow eyes of medium depth for Marabel and shallow for Desiree. Although the commercial varieties produce tubers with good flavour and suitable for different culinary use, local varieties, including the less productive, are part of the culinary tradition in the cultivated area and therefore have a flavour that is most appreciated by end consumers. Particularly, Patata Rossa di Terranova di Pollino, is characterized by a compact, dry tannery, especially tasty and usable for any culinary use (from roasted, sliced into chips or wedges or used in salads or mashed) while, among varieties coming from San Severino Lucano municipality, Marca is of particular interest because it is floury but does not flake during the cooking process and it is considered ideal for bread-making, typically produced with Marca or Paesana varieties and included in the Traditional Food Products.

CONCLUSION

The local varieties of potatoes grown in Pollino National Park (Italy) have shown appreciable vegetative and productive performances, with Patata Rossa di Terranova di Pollino (that is listed in the Traditional Food Products) and Patata Bianca di Terranova di Pollino being the most productive. This latter, together with Marca and Casale (traditionally cultivated in small areas of the municipality of San Severino Lucano and at risk of erosion) were also distinguished for the greater production of medium-large tubers. The results obtained demonstrated a great adaptability also in the commercial varieties Marabel and Desiree to the pedo-climatic conditions of the high altitude areas of the park, providing similar tuber production to those obtained in other areas of cultivation and of diverse altitudes.

Considering the appreciable production and tuber characteristics (in terms of unit weight and size) of the local potato varieties and the excellent recognised organoleptic characteristics typically of the potato cultivated in the mountains (greater dry matter and starch), the qualitative and nutritional characteristics of local genotypes should be further analyzed with the aim to sustain the protection and preservation of such biodiversity.

SIGNIFICANCE STATEMENTS

The study provides the first data on production and characteristics of different ancient local potato genotypes. Data can be beneficial for further studies into the qualitative and nutritional features of the tubers to concretely promote local germplasm conservation.

REFERENCES

1. FAO., 2015. Statistical Pocketbook 2015: World Food and Agriculture. Food and Agriculture Organization (FAO), Rome, Italy, ISBN: 978-92-5-108802-9, Pages: 236.
2. FAO., 2008. International year of the potato 2008: New light on a hidden treasure. An end-of-year review. Food and Agriculture Organization (FAO), Rome, Italy, pp: 1-148.
3. Brown, C.R., 2005. Antioxidants in potato. Am. J. Potato Res., 82: 163-172.
4. Camire, M.E., S. Kubow and D.J. Donnelly, 2009. Potatoes and human health. Crit. Rev. Food Sci. Nutr., 49: 823-840.
5. King, J.C. and J.L. Slavin, 2013. White potatoes, human health and dietary guidance. Adv. Nutr., 4: 393S-401S.
6. Lutaladio, N. and L. Castaldi, 2009. Potato: The hidden treasure. J. Food Compos. Anal., 22: 491-493.
7. Jimenez, M.E., A.M. Rossi and N.C. Samman, 2009. Phenotypic, agronomic and nutritional characteristics of seven varieties of Andean potatoes. J. Food Compos. Anal., 22: 613-616.
8. Te Wierik, G.H.P., J. Bergsma, A.W. Arends-Scholte, T. Boersma, A.C. Eissens and C.F. Lerk, 1996. A new generation of starch products as excipient in pharmaceutical tablets. I. Preparation and binding properties of high surface area potato starch products. Int. J. Pharmaceut., 134: 27-36.
9. Ranjbar, M. and M. Mirzakhan, 2012. Response of agronomic and morphologic characteristics of commercial and conventional potato cultivars to green house condition. Int. J. Agric. Crop Sci., 4: 333-335.
10. Scott, G.J., 2011. Plants, people and the conservation of biodiversity of potatoes in Peru. Natureza Conservacao, 9: 21-38.
11. Cadima, X., M. van Zonneveld, X. Scheldeman, N. Castabeda, F. Patino, M. Beltran and P. van Damme, 2014. Endemic wild potato (*Solanum* spp.) biodiversity status in Bolivia: Reasons for conservation concerns. J. Nat. Conserv., 22: 113-131.
12. Elia, A. and P. Santamaria, 2013. Biodiversity in vegetable crops, a heritage to save: The case of Puglia region. Ital. J. Agron., 8: 21-34.
13. Hammer, K. and G. Laghetti, 2005. Genetic erosion-examples from Italy. Genet. Resour. Crop Evol., 52: 629-634.
14. Belhjati, S., R. Choukan, H. Hassanabadi and B. Delkhosh, 2013. The evaluation of yield and effective characteristics on yield of promising potato clones. Ann. Biol. Res., 4: 81-84.
15. Fetena, S. and B. Eshetu, 2017. Evaluation of released and local potato (*Solanum tuberosum* L.) varieties for growth performance. J. Agron., 16: 40-44.
16. Figliuolo, G. and D. Cerbino, 2014. Agro-biodiversity spatial assessment and genetic reserve delineation for the Pollino National Park (Italy). Nat. Resour., 5: 308-321.
17. Montesano, V., D. Negro, G. Sarli, G. Logozzo and P.S. Zeuli, 2012. Landraces in Inland areas of the Basilicata region, Italy: Monitoring and perspectives for on farm conservation. Genet. Resour. Crop Evol., 59: 701-716.
18. Figliuolo, G., D. Cerbino, S. Gallo, P. Zienna and A. Laguardia *et al*., 2010. Gli antichi fruttiferi del Pollino. Quaderni Alsia, Agenzia Lucana Sviluppo and Innovazione in Agricoltura, Year X, Matera, Italy, pp: 1-110.
19. Figliuolo, G., D. Cerbino, S. Gallo, P. Zienna and A. Laguardia *et al*., 2012. Le antiche varieta orticole e cerealicole del Pollino. Quaderni Alsia, Agenzia Lucana Sviluppo and Innovazione in Agricoltura, Year XII, Matera, Italy, pp: 1-110.
20. Wurr, D.C.E., J.R. Fellows and E.J. Allen, 1992. Determination of optimum tuber planting density in the potato varieties Pentland Squire, Cara, Estima, Maris Piper and King Edward. J. Agric. Sci., 119: 35-44.
21. Wurr, D.C.E., J.R. Fellows and E.R. Allen, 1993. An approach to determining optimum tuber planting densities in early potato varieties. J. Agric. Sci., 120: 63-70.
22. Fleisher, D.H., D.J. Timlin and V.R. Reddy, 2006. Temperature influence on potato leaf and branch distribution and on canopy photosynthetic rate. Agron. J., 98: 1442-1452.
23. Beukema, H.P. and D.E. van der Zaag, 1990. Introduction to Potato Production. 2nd Edn., Centre for Agricultural Publishing and Documentation (PUDOC), Wageningen, The Netherlands, ISBN: 9789022009635, Pages: 208.
24. Pedersen, S.M., J. Bizik, L.D. Costa, J. Coutinho, F. Dolezal and A. Gluska, 2005. Potato production in Europe-a gross margin analysis. FOI Working Paper No. 5, Fodevareøkonomisk Institut, Kobenhavns Universitet, Frederiksberg, Denmark, pp: 1-39.
25. Bussan, A.J., P.D. Mitchell, M.E. Copas and M.J. Drilias, 2007. Evaluation of the effect of density on potato yield and tuber size distribution. Crop Sci., 47: 2462-2472.
26. Sanli A., T. Karadogan, S. Erbas and B. Tosun, 2015. The effects of plant density and eye number per seed piece on potato (*Solanum tuberosum* L.) tuber yield. Scient. Pap. Ser. A: Agron., 58: 325-331.