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The nutritive value and role of *Panicum turgidum* Forssk. in the arid ecosystems of the Egyptian desert

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Panicum turgidum is one of the most drought resistant plants in the Egyptian desert. Five habitat types were selected for the study: sand dunes (North Sinai and in Wady El-Natrun), gravel desert, coastal plain, and water runnels of a wadi bed (South Sinai and Eastern Desert). About 47.4% of the studied sites were subjected to high grazing pressure, 26.3% to moderate grazing pressure; the remaining 26.3% were subjected to low grazing pressure. Concentration of the nutrients (K, Na, Ca, P and Ca/P ratio) in the grazeable parts of *P. turgidum* populations exhibited insignificant variability between habitats and phytogeographical regions. Meanwhile, concentration of potassium showed significant variability between the phytogeographical regions. Ca/P ratio of the grazeable parts of *P. turgidum* was significantly related to the soil silt and organic matter content. The percentage of crude protein was higher than the minimum required for the maintenance of the grazing animals, i.e. *P. turgidum* has a good or excellent forage quality. Due to its high nutritive value and ease of cultivation, *P. turgidum* grains could be considered as a potential crop, which may serve as a supplementary food to the common cereals. It worth noting that the variation in the nutritive values among the cultivated populations was insignificant as all the cultivated populations had a high nutritive value, indicating the effect of edaphic factors on the wild population nutritive value which was proved also from the correlation between the edaphic factors and nutritive variable.

Keywords: arid, grazing, protein, nutrients, desert, Egypt.

Introduction

Grasses play an important role in land stabilization and animal nutrition due to their protein, carbohydrates, fats, fibers and mineral contents. Therefore, planting grasses constitutes an important part of any rangeland rehabilitation program. *Panicum turgidum* Forssk. (Poaceae) is one of the widely distributed and most drought resistant grasses of the Egyptian desert (MIGAHID and EL SHOURBAGY 1961). According to TÄCKHOLM (1974), this species is widely distributed in all phytogeographical regions of Egypt except the western Mediterranean coastal desert. The success and wide distribution of this plant species indi-

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cates its ability to tolerate certain unfavorable conditions (ISMAIL and SEED 1983). *Panicum turgidum* has the merit of being very resistant to drought and also a very effective sand-binding xerophyte (MIGAHID and EL SHOURBAGY 1961). It is also considered to be tolerant to high soil salinity levels as well as to sand accumulation. Therefore, it is a good species for stabilizing loose soil (EL SHOURBAGY 1958, HENEIDY and WASEEM 2007).

Due to the high palatability of this grass it is considered an important fodder and grazing plant for many animals, especially in summer when annuals disappear and shortage in natural forage occurs. Also, in dry conditions, *P. turgidum* provides grazing as standing hay (MANDAVILLE 1990). Since many native grasses of the coastal strip of Egypt are spring growers, the summer growth of *P. turgidum* may make this species suitable as complementary forage for the deteriorated lands of the western coastal desert of Egypt. The present study aims at assessing the variation in the nutritive value among the studied populations of *P. turgidum* and its relation to soil characters. Consequently, it has successfully been used in rehabilitation trials in the western coastal deserts of Egypt (HENEIDY and WASEEM 2007).

Materials and methods

Fresh specimens of *P. turgidum* were collected from 19 sites, selected to represent a wide variety of habitats within the range of distribution of *P. turgidum* in the Eastern Desert, Wady El-Natrun and Sinai (Tab. 2). According to TÄCKHOLM (1974) these sampling sites are located in four different phytogeographical regions: the Eastern Desert region; Mediterranean region (north Sinai); Oases of the Western Desert (Wady El-Natrun); and Sinai proper (Fig. 1). The sampling site represents five types of habitats: sandy plains; sand dunes (sampling populations located in North Sinai and in Wady El-Natrun), gravel desert, coastal plain, and water runnels of the wadi bed (sampling populations located in South Sinai and Eastern Desert). Pasture condition, grazing pressure and the relative abundance of *P. turgidum* were assessed for the nineteen sampling sites, by direct observations during the field visits. Relative accessibility of the aboveground parts of the studied species for grazing was assessed using the ocular estimate method (ETIENNE 1989). The aboveground parts of *P. turgidum* in each site were assigned to one of the relative accessible parts classes; 40–59, 60–89 and 90–100% (JENSEN and SCOTTER 1977).

For the chemical analysis and nutritive value estimation, samples of the fresh grazeable aboveground parts of the studied species populations were collected from at least five bushes from each of the sampling sites. The collected plant materials were cleaned, oven dried at 65 °C to constant weight, powdered before chemical analysis. Mature grains collected from all the studied populations were pooled together to form a composite sample. The grains were powdered ready for chemical analysis. The mixed-acid digestion was used for preparing the sample solution for determination of element content. Na, K, Ca and Mg were analyzed using the flame photometer. Phosphorous was determined according to EATON et al. (1995). Ash and ether extract (i.e. crude fats) was determined according to ALLEN et al. (1974). Total protein was determined according to the modified Lowery method (HARTREÉ 1972). The crude fiber was determined according to AOAC (1960). Nitrogen free extract was calculated according to the following equation (LE HOUÉROU 1980):

$$NFE \text{ (in \% DM)} = 100 - (CP + CF + EE + Ash)$$

where CP = crude protein, CF = crude fibers, EE = ether extract (i.e. total fats).

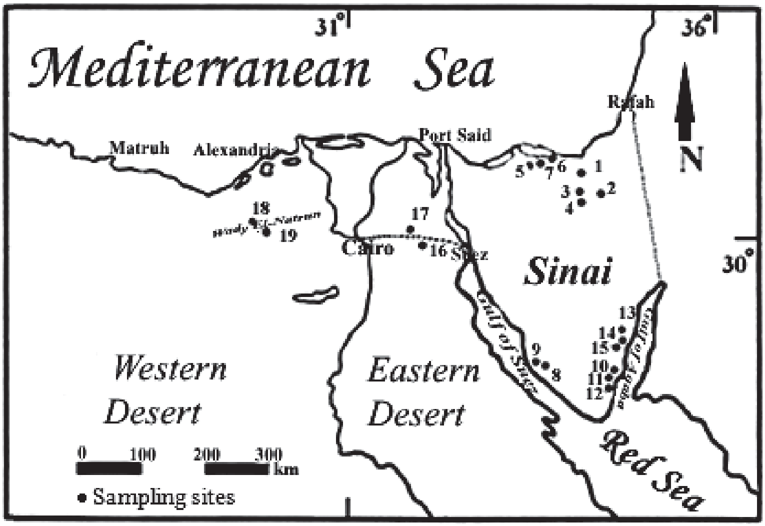

Fig. 1. Map of northern Egypt showing the locations of the sampling sites from which *P. turgidum* populations were collected. **1-** Bir Lahfen; **2-** El-Koseima road; **3-** Abu Aekela; **4-** Geble Libni; **5-** Spika; **6**- Ras El-Deeb (El Zaranik protected area); **7-** El Zaranik protected area; 8- El-Qaa plain (15 Km from El-Tur city); **9-** El-Qaa plain (35 Km from El-Tur city); **10-** Wadi Kid, Rahila road (Nabq protected area); **11-** Wadi Kid (Nabq protected area); **12-** Wadi Kid, Khashm El-Fakh (Nabq protected area); **13-** Wadi El Sokhen (Abu Galum protected area); **14-** Wadi Mamlah (Abu Galum protected area); **15**- Wadi El Rasassa (Abu Galum protected area); **16-** Km 101, Cairo-Suez Road; **17**- Km 75, Cairo-Suez Road; **18-** West of Al-Gaar Lake (Wady El Natrun); **19-** East of Um-Risha Lake (Wady El Natrun).

Digestible crude protein (DCP) was determined using the equation of DEMARQUILLY and WEISS (1970):

$$\text{DCP (in \% DM)} = 0.93\,\text{CP} - 3.52$$

This equation is only valid in the case of nitrogen concentration from 0.61 to 3% (or CP > 3.81%). Total digestible nutrients (TDN) were estimated according to ABU EL-NAGA and EL-SHAZLY (1970). The gross plant energy was calculated from its chemical analysis components multiplied by the average of heat of combustion (LOFGREEN 1951). Digestible and metabolized energy (DE and ME) were estimated according to CRAMPTON and HARRIS (1969). Net energy was estimated according to GARRETT (1980).

Three soil samples were taken down to the depth of 0–50 cm for each site. Soil samples were air dried, thoroughly mixed, passed through a 2 mm sieve before physical and chemical analysis (BLACK 1965, ALLEN et al. 1974). Soil texture analysis was conducted using the Bouyoucus hydrometer method. Determination of calcium carbonate content was carried out using a calcimeter. Total organic matter was determined by loss-on-ignition. For determination of soil reaction (pH), electric conductivity (E.C.), bicarbonates and some of the available nutrients 1: 2.5 (w/v) soil: water extracts were prepared. Sulfates were carried out using the »gravimetric with ignition of residue method«. Calcium and magnesium were determined using direct titration against 0.1N EDTA. A flame photometer was used for determination of K and Na. Phosphorous was determined using the ascorbic acid method according to EATON et al. (1995).

The significance of variation in the soil parameters, chemical constituents and nutritive variables of the plant materials in relation to habitat and to the phytogeographical regions was assessed using one-way ANOVA test. Simple linear correlation analysis was applied to detect the relationship between the chemical composition and nutritive variables of the studied populations and the soil parameters of the sampling sites to investigate the influence of soil characteristics on the plant chemical composition and hence on its nutritive values.

Two multivariate analysis techniques (classification and ordination) were conducted on the data of the chemical composition and the nutritive variables of the plant materials of the studied populations. One way-ANOVA test was applied for the soil parameters of the resulting groups from cluster analysis. The significance of variation in chemical composition and nutritive variables among the cultivated populations were assessed using one-way ANOVA test. All the statistical analyses were conducted with the Minitab 13.1 release-PC computer program (MINITAB 2000).

Results

Habitat characteristics

The soil characteristics of the studied habitats and the phytogeographical regions from which *P. turgidum* populations were collected showed variation among the different habitats and the phytogeographical regions (Fig. 2, 3). The soil of sampling sites was generally alkaline with pH ranging from 7.71 to 8.22. The pH- value exhibited significant variation between habitats while it showed insignificant variation between phytogeographical regions (Tab. 1). The soil texture varied from loamy sand to sandy. Calcium carbonate content, sand, silt and clay percentages showed significant variation between different habitats and also between phytogeographical regions. Potassium content showed significant variation between habitats and insignificant variation between phytogeographical regions. Bicarbonate and phosphorus content of the soil showed significant variation between habitats and also between phytogeographical regions. Generally, all the studied soil parameters showed significant difference between the studied habitats and also between the phytogeographical regions from which *P. turgidum* was collected, with the exception of the pH and the potassium content, which did not show any significant variation between the phytogeographical regions.

Tab. 1. One way-ANOVA testing the significance of variation in soil characteristics among the phytogeographical regions and among the investigated habitats from which *P. turgidum* was sampled. • significant $P < 0.05$; •• very significant $P < 0.01$; and ••• highly significant $P < 0.001$

	pH	(%)				mg/ 100g		
		$CaCO_3$	Sand	Silt	Clay	K	HCO_3	P
Phytogeographical regions	3.21	4.69•	8.49•••	6.75••	6.45••	3.01	5.16•	4.99•
Habitats	3.92•	29.02•••	6.01••	4.90•	9.96•••	3.86•	11.71•••	16.24•••

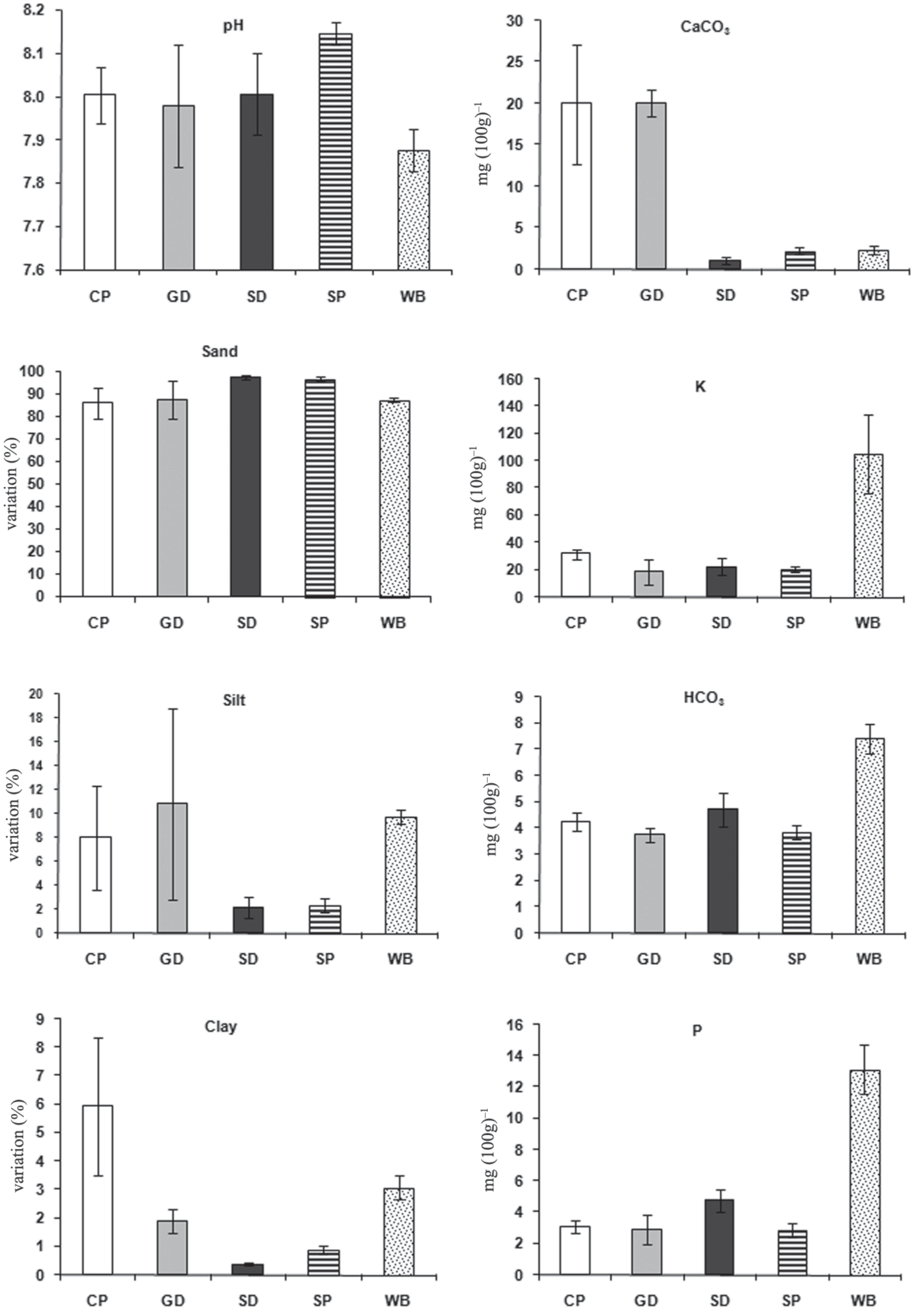

Fig. 2. The variation in soil parameters between the studied habitats (CP: coastal plain; GD: gravel desert; SD: sandy dunes; SP: sandy plain; and WB: wadi bed) of the studied *P. turgidum* populations.

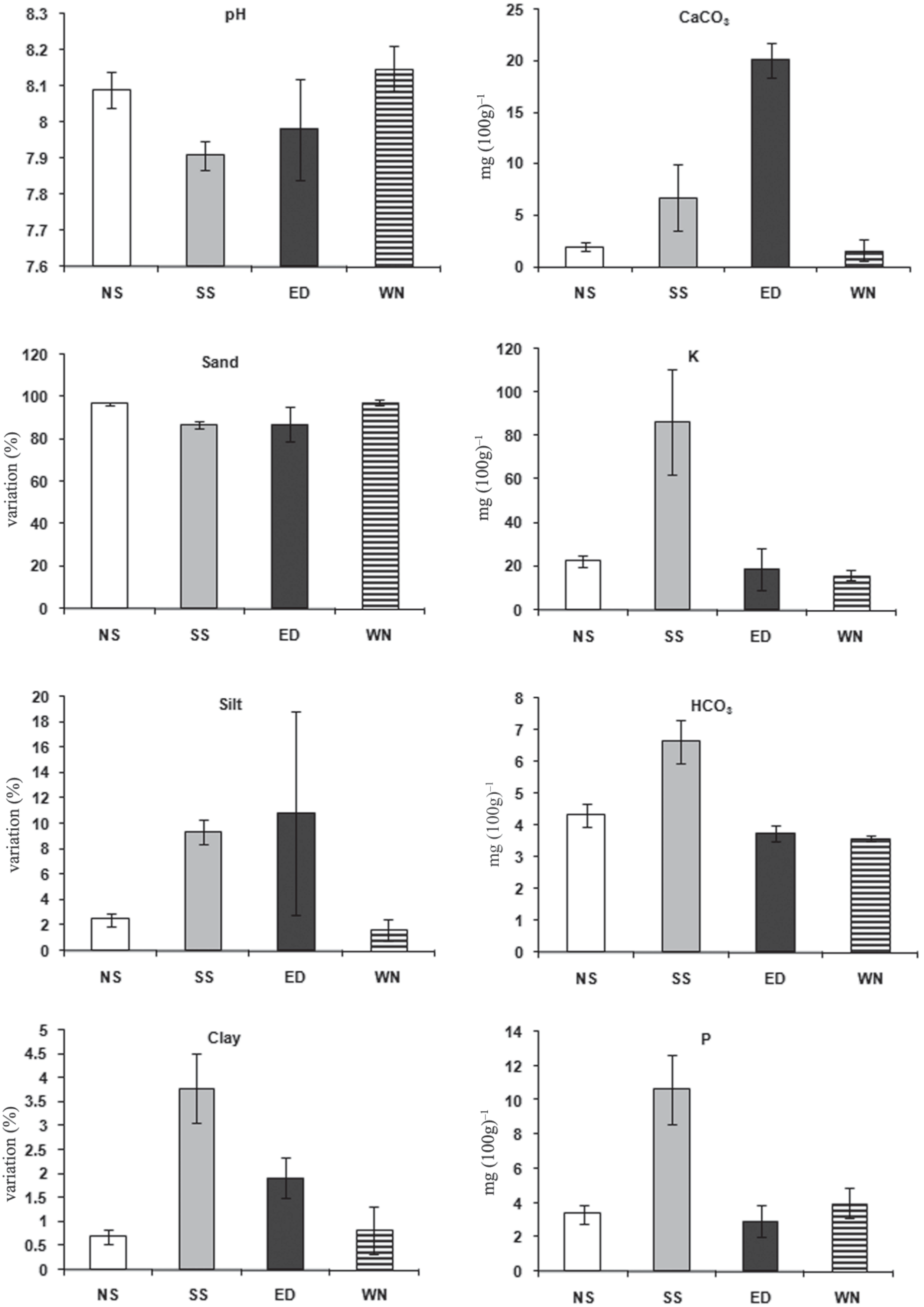

Fig. 3. The variation in soil parameters between the studied phytogeographical regions (NS: North Sinai; SS: South Sinai; ED: Eastern Desert and WN: Wady El-Natrun) from which *P. turgidum* populations was sampled.

Tab. 2. Description of the sampling sites from which *P. turgidum* populations were collected, the relative accessibility of the above-ground parts and the relative abundance of *P. turgidum* in each site (*cc= very common, c; common).

Site	Region	Habitat	Soil texture	Pasture condition	Grazing pressure	Relative accessi-bility (%)	*Relative Abundance
1	North Sinai	Sandy plain, with deep very fine sand deposits	Sandy	Good	High	60–89	c
2	North Sinai	Sandy plain, with deep very fine sand deposits	Sandy	Good	High	90–100	c
3	North Sinai	Sandy plain, with very deep sand deposits	Sandy	Good	High	60–89	c
4	North Sinai	Sandy plain, with very deep sand deposits	Sandy	Poor	High	60–89	cc
5	North Sinai	Sand dune	Sandy	Fair	Mode-rate	60–89	cc
6	North Sinai	Sand dune	Sandy	Fair	Low	40–59	cc
7	North Sinai	Sand dune	Sandy	Fair	Low	40–59	cc
8	South Sinai	Coastal plain, drainage lines of the plain covered with alluvial deposits	Loamy sand	Good	Mode-rate	90–100	c
9	South Sinai	Coastal plain, drainage lines of the plain covered with alluvial deposits	Sandy	Good	High	60–89	cc
10	South Sinai	Wadi bed, drainage lines of the wadi covered with alluvial deposits	Loamy sand	Fair	Mode-rate	90–100	cc
11	South Sinai	Wadi bed, mouth of the wadi covered with alluvial deposits	Sandy	Good	High	90–100	cc
12	South Sinai	Wadi bed, drainage lines of the wadi covered with alluvial deposits	Sandy	Good	High	60–89	cc
13	South Sinai	Wadi bed, mouth of the wadi covered with alluvial coarse deposits mainly boulders and gravels	Loamy sand	Fair	High	60–89	cc
14	South Sinai	Wadi bed, mouth of the wadi covered with alluvial coarse deposits mainly boulders and fine gravels	Sandy	Fair	High	60–89	cc
15	South Sinai	Wadi bed, mouth of the wadi covered with alluvial coarse deposits mainly boulders and gravels	Loamy sand	Fair	Mode-rate	90–100	cc
16	Eastern Desert	Gravel and sand formations, drainage lines of the gravel desert covered with fine deposits	Sandy	Fair	Mode-rate	60–89	cc
17	Eastern Desert	Gravel and sand formations, drainage lines of the gravel desert covered with fine deposits	Loamy sand	Fair	Low	60–89	c
18	Wady El Natrun	Sandy plain, with fine deep sand deposits	Sandy	Fair	Low	40–59	cc
19	Wady El Natrun	Sandy plain, with fine deep sand deposits	Sandy	Good	Low	60–89	cc

Grazing status and pasture condition

Generally, pasture conditions can be classified as poor, fair and good. About 42.1% of the studied sites (1, 2, 3, 8, 9, 11, 12, and 19) are considered good pastures. At the same time 52.6% of the studied sites (5, 6, 7, 10, 13, 14, 15, 16, 17 and 18) were fair in pasture condition, while site 4 had a poor pasture condition. Grazing pressure in the studied populations ranged from low to high (Tab. 2). About 47.4% of the studied sites (1, 2, 3, 4, 9, 11, 12, 13 and 14) were subjected to high grazing pressure (Tab. 2), while 26.3% of the studied sites (5, 8, 10, 15 and 16) were subjected to moderate grazing pressure. The remaining 26.3% of the studied sites (6, 7, 17, 18 and 19) were subjected to low grazing pressure. The relative accessibility of the aboveground parts of *P. turgidum* for grazing (by which we mean the ratio of the green to the dry old shoots in each plant bush) ranged from 60 to 89% in most of the sampling sites (1, 3, 4, 5, 9, 12, 13, 14, 16, 17 and 19). The highest relative accessibility (>90%) was recorded in sites number 2, 8, 10, 11 and 15, while sites number 6, 7 and 18 acquired the lowest values (40–59%). The coastal plain, the water runnels of the wadi bed and the gravel desert showed a higher percentage of accessible parts than the sandy plain and sand dunes habitats. The relative abundance of the studied species in all the examined sampling sites was very common in 73.7% of the studied sites and common in the rest of the populations. The relative accessibility of the aboveground parts of the plant was high in moderately and highly grazed sites, while it was low in areas with low grazing pressure.

Chemical composition of the studied populations

The variation of the different nutrients in the grazeable parts of *P. turgidum* populations between the investigated habitats and phytogeographical regions in nutrients content of the studied populations were insignificant except for potassium content, which exhibited significant variation in the different phytogeographical regions (Tab. 3). It is obvious that populations of *P. turgidum* collected from Eastern desert region attained a maximum mean sodium and potassium contents (1.04, 1.32% respectively), while those collected from north Sinai region attained maximum mean calcium, magnesium and phosphorus contents (1.37, 0.91 and 0.29% respectively). Populations collected from south Sinai region attained the maximum mean Ca/Mg and Ca/P ratios (1.70 and 5.71 respectively; Fig. 4).

Generally, the studied populations collected from the Eastern desert region attained the highest mean values of ether extract and crude protein content (2.7 and 7.6% respectively; Fig. 4). North Sinai populations attained the highest mean values of ash and crude fiber content (9.6 and 37.5% respectively). On the other hand, the studied *P. turgidum* populations collected from Wady El-Natrun region attained the highest mean values of nitrogen free extract (46.4%). A highly significant variation in the total carbohydrates content (NFE) was established among the phytogeographical regions, while the variation in crude fiber and in crude protein content in the different habitats was significant (Tab. 3). The variation in the ash and fat content of the grazeable parts of the studied *P. turgidum* populations is not significant among either the habitats or the phytogeographical regions.

Nutritive value assessment of the studied population

In general, Eastern desert populations showed the maximum mean of digestible crude protein content (3.53%; Fig. 4). The studied *P. turgidum* populations of Wady El-Natrun re-

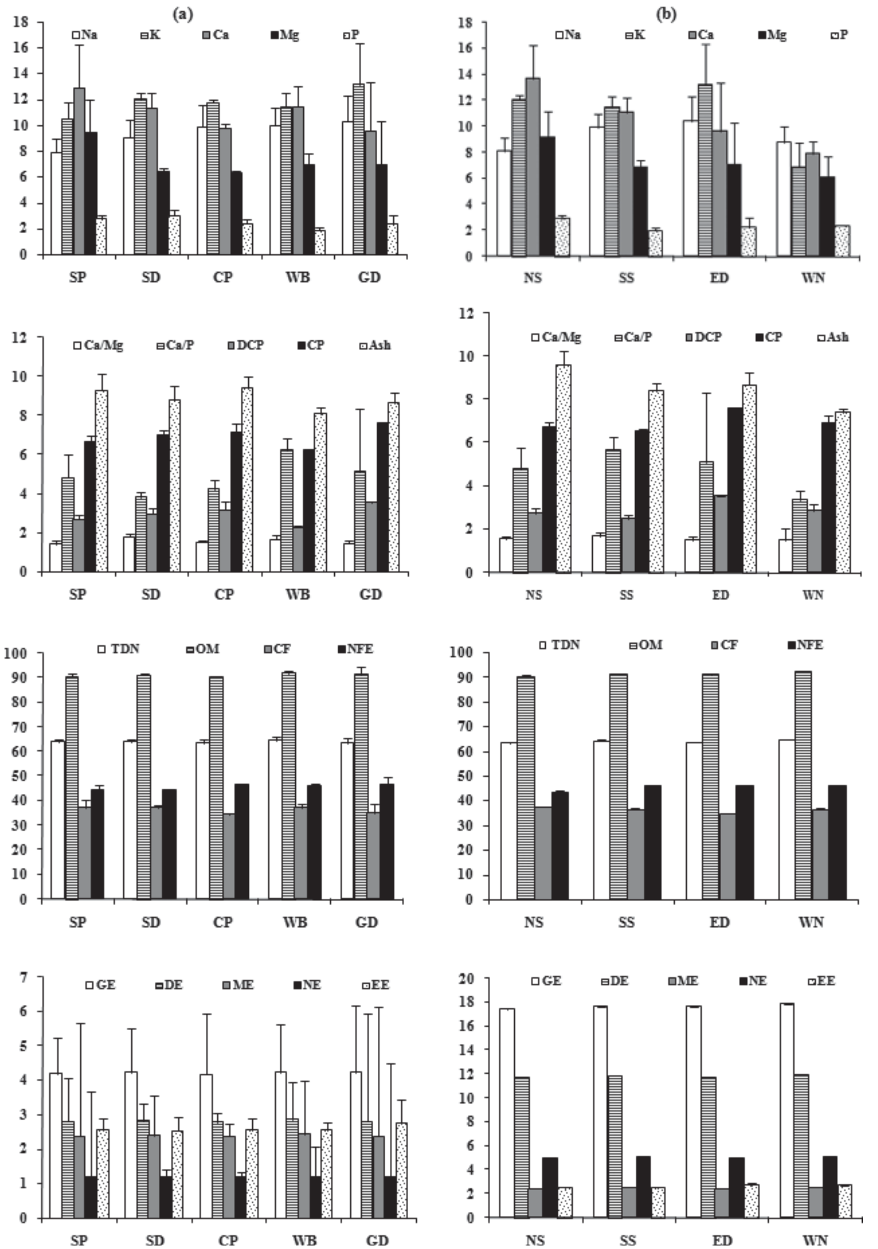

Fig. 4. The variation in the nutrients in mg/g, ash (%), Ca/Mg, Ca/P ratio, metabolic constituents (EE: ether extract (%), CF: crude fiber (%), CP: crude protein (%), NFE: nitrogen free extract (%) and OM: total organic matter (%) and nutritive variables (DCP: digestible crude protein (%), TDN: total digestible nutrients (%), GE: gross energy (Mcal kg^{-1} DM), DE: digestible energy (Mcal kg^{-1} DM), ME: metabolized energy (Mcal kg^{-1} DM), and NE: net energy (Mcal kg^{-1} DM) among **(a)** the studied habitats (SP: sandy plain; SD: sandy dunes; CP: coastal plain; WB: wadi bed; and GD: gravel desert) and **(b)** the studied phytogeographical regions (NS: North Sinai; SS: South Sinai; ED: Eastern Desert and WN: Wady El-Natrun).

Tab. 3. One way-ANOVA testing the significance of variation in the content of nutrients, Ca/Mg, Ca/P ratios, ash, ether extract (EE), crude fiber (CF), crude protein (CP), nitrogen free extract (NFE), total organic matter (OM), digestible crude protein (DCP), Total digestible nutrients (TDN), gross energy (GE), digestible energy (DE), metabolized energy (ME) and net energy (NE) in the aboveground parts of *P. turgidum* among the phytogeographical regions and among the investigated habitats from which *P. turgidum* was sampled. • significant, P < 0.05; •• very significant, P < 0.01; and ••• highly significant, P < 0.001.

Parameter		Phytogeographical Regions	Habitats
mg g^{-1}	Na	0.65	0,09
	K	**3.81•**	0.42
	Ca	0.89	0.21
	Mg	0.57	0.47
	P	2.34	1.61
	Ca/Mg	0.22	0.48
	Ca/P	0.61	0.67
%	Ash	1.94	0.64
	EE	0.81	0.26
	CF	2.58	**6.82••**
	CP	2.11	**3.60•**
	NFE	**7.38••**	1.92
	OM	1.95	0.58
	DCP	2.11	**3.60•**
	TDN	1.93	1.41
Mcal kg^{-1}	GE	1.35	0.38
	DE	1.99	1.63
	ME	1.99	1.63
	NE	1.8	1.26

gion had the maximum of mean total digestible nutrients (64.91%), gross energy (4.27 Mcal kg^{-1} DM), digestible energy (2.85 Mcal kg^{-1} DM), metabolized energy (2.44 Mcal kg^{-1} DM), and net energy (1.22 Mcal kg^{-1} DM). The digestible crude protein showed significant variation among the studied habitats (Tab. 3).

The correlation analysis between the chemical compositions, nutritive variables of the studied wild populations of *P. turgidum* and the soil parameters of the sampling sites from which these populations were collected (Tab. 8) reveals significant negative relationship between the bicarbonate content of the soil, the digestible crude protein content and the crude protein content of the plant. A highly significant negative relationship existed between the crude fiber content of the studied population and the calcium carbonate content of the soil. The Ca/Mg ratio of the studied population showed a significant negative relationship with the pH of the soil, while exhibiting a significant positive relationship with magnesium and potassium content of the soil. The Ca/P ratio of the studied populations exhibited a significant positive relationship with the organic matter and the silt content of soil. The digestible energy and the metabolized energy of the studied populations exhibited a significant positive relationship with the phosphorous content of the soil.

Discussion

The variation in the accessible aboveground parts of P. *turgidum* among the different sites with different grazing levels may be attributed to the variation in the physical configuration of the plant (the ratio between the green to dry old shoots) in the highly grazed sites compared to low-grazed sites. The plant bushes in the low-grazed sites were characterized by being very tangled, with large accumulations of dry old branches. This is in agreement with VALENTINE (1990). He indicated that some of the positive effects of grazing are the increase in nutritive value of grasses by increasing the ratio of new growth: old growth, removal or prevention of thatch buildup and reduction of the accumulation of dry old shoots that may stunt new growth.

In the present study, the forage value of *P. turgidum* was evaluated according to its chemical composition. According to LE HOUÉROU (1980) the forage value of the consumed plant is the result of its nutritive value, i.e. chemical composition and digestibility. It is highly affected by the stage of maturity, edaphic influence; climate and range condition. In addition, the nutritive value of any forage is dependent upon its content of energy-producing nutrients as well as its contents of physiologically essential nutrients (SHALTOUT and EL-BEHEIRY 1997).

The concentration of nutrients varied from population to another, which may be attributed to the variation in the edaphic and climatic factors. The results of the present study showed that the Ca/P ratio of the grazeable parts of *P. turgidum* was significantly related to the soil silt and organic matter content (Tab. 8). On other hand, Ca/Mg ratio was significantly related to soil magnesium, potassium content and soil reaction (pH**).** This agrees with the reported accumulation of nutrients in the grazeable phytomass of a species that may differ considerably from one habitat to other (ABDEL-RAZIK et al. 1988b).

It is worth noting that the Ca/Mg ratio in the grazeable parts of *P. turgidum* in the present study was comparable to the mean of the natural forage in the western Mediterranean coastal rangelands (Tab. 4). However, according to BOUDET (1975) the Na, K, Ca, Mg and P contents of *P. turgidum* meet the level required for the maintenance of animals. In addition,

Tab. 4. Nutrients contents (%), Ca/Mg and Ca/P ratios of the studied wild *P. turgidum* populations compared to other related studies, to the maximum tolerable level and to the maintenance level of these nutrients required for animal feed.

Panicum turgidum	**Determined by**	**(%)**					**Ca/P**	**Ca/Mg**
		Na	**K**	**Ca**	**Mg**	**P**		
Mean of the studied wild populations	Present Study	0.92	1.14	1.15	0.76	0.24	5.07	1.57
Wadi Eithely (Eastern Desert)	KABIEL (2001)	0.31	0.69	0.78	0.26	0.25	–	–
Western Mediterranean coastal rangelands (El Omayed)	ABDEL-RAZIK et al. (1988b)	0.87	1.68	2.95	2.23	0.09	32.6	1.34
Maintenance levels	BOUDET (1975)	0.08	0.4	0.2	0.2	0.12	–	–
Maximum tolerable level	NRC (1984)	10	3	2	4	1	–	–

according to NRC (1984) the *P. turgidum* Na, K, Ca and P content does not exceed the maximum tolerable level (Tab. 4). Comparing the mean of the composition of nutrients of *P. turgidum* in all the studied wild populations with the mean of natural forage in the western Mediterranean coastal rangeland – the most important rangelands in Egypt according to EL-KADY (1987) – showed that the concentration of K, Ca, and Mg is lower than that of the mean of natural forage in the western Mediterranean coastal rangeland (Tab. 4). However, the phosphorus content is much higher than that of the mean of natural forage in the western Mediterranean coastal rangeland. *P. turgidum* is characterized by the association of mycorrhizae (vesicular-arbuscular type) with its roots as stated by KHALIEL (1989) and SRIVASTAVA et al. (1997), which may explain the high content of phosphorous in *P. turgidum*. It was asserted by PENNING DE VRIES et al. (1980) that if too little P is available, the N absorption, and hence production are reduced. This demonstrates the importance of introducing *P. turgidum* in the western Mediterranean coastal rangelands to compensate for the deficiency in phosphorous, the only element in which the forage of this region is deficient according to ABDEL-RAZIK et al. (1988a). The importance of the adequate Ca/P ratio of 2–3 is considered by AYYAD and LE FLOC'H (1983) to be a major factor affecting the utilization of the whole animal diet. In addition, the high Ca/P ratio leads to lower utilization of both Ca and P. According to ABDEL-RAZIK et al. (1988b) the mean Ca/P ratio of the natural forage in the western Mediterranean coastal rangelands is notably high (32.6). In the present study, Ca/P ratio ranged from 3.36 in *P. turgidum* populations collected from Wady El-Natrun to 5.71 in those of South Sinai; this low Ca/P ratio gives a further reason for the introduction of *P. turgidum* as a natural forage plant in the western Mediterranean region.

Crude protein (CP) and crude fibers (CF) are viewed classically as an indicator of the nutritional value of food for grazing animals (BRYANT and KUROPAT 1983, HENEIDY 2002). The percentage of crude protein in the grazeable parts of the studied wild *P. turgidum* populations is higher than the minimum (6% of forage dry matter) required for the maintenance of animals, if compared with many tropical grasses (Tab. 5). The crude fiber (CF) content of the grazeable parts of the studied *P. turgidum* populations was quite high. It ranged from 34.8% in Eastern desert to 37.5% in north Sinai (Fig. 4). The mean value of the studied wild populations (36.7%) was higher than that obtained by KABIEL (2001), but lower than that obtained by FAROOQ et al. (1989) and HENEIDY (1996). The importance of lipids (ether extract or EE) to plants in terms of structure and use in metabolism is well known.

Tab. 5. Ash, ether extract (EE), crude protein (CP), crude fiber (CF) and nitrogen free extract (NFE) contents (%) of the studied wild *P. turgidum* populations compared to other related studies and to cultivated *P. turgidum*.

Panicum turgidum	**Determined by**	**(%)**				
		Ash	**EE**	**CP**	**CF**	**NFE**
Mean of the studied wild populations	Present Study	8.8	2.5	6.7	36.7	45.2
Mean of cultivated populations		7.7	3.7	9.2	31.4	48.1
Peshawar (Pakistan)	FAROOQ et al. (1989)	12.2	2.2	6.5	37.4	37.4
Gulf of Aqaba (Sinai)	HENEIDY (1996)	9.1	5.3	6.6	39.9	39.4
Wadi Eithely	KABIEL (2001)	12.1	2.3	4.8	35.1	45.7

The development of mankind has reached the point at which a variety of new resources need to be tapped in order to fill the basic needs for food and feed, especially in the developing countries (LIETH 2002). Information on the seeds of wild species and wild relatives of cultivated crops is scarce but with the increasing interest in new food sources and the use of genetic diversity in breeding programs, the seeds of wild plants are now receiving more attention (IRIONDO and PÉREZ 1997). Wild plants have provided a safety net for human beings from time immemorial, whenever crop harvests were poor. They are consumed daily and traded at markets through special rural-urban marketing channels. In addition, some of the wild plants play an important food security role in the time of famine (e.g. *Cenchrus biflorus* and *P. turgidum*). The results of this study indicated that *P. turgidum* grains are characterized by high nutritive value comparable to that of the common cereals (corn, wheat and barley, Tab. 6) and other cultivated grain-producing grasses. Many scientists (IRVINE 1952, WILLIAMS and FARIAS 1972, HARLAN et al. 1989) reported that the local inhabitants of the Western Sahara use and eat the grains of *P. turgidum*, grinding the grains into flour, using it in making porridges and baking it into bread. Grain shattering is one of the main problems, resulting in low yield. Generally, in many grasses the cleaning of the grains is necessary to obtain adequate grain quality. Unfortunately grains of most species of tropical pasture grasses are characterized by being very difficult to thresh and to clean because of the strong attachment of palea and lemma to the caryopsis (e.g. *Stipagrostis plumose*, *Lasuirus sindicus* and *Cenchrus ciliaris*). This makes these species difficult to domesticate (LE HOUÉROU 1985). However, it was noticed that *P. turgidum* grains are very easy to thresh and to clean. Accordingly, *P. turgidum* grains could be considered as a potential crop, and it may serve as a supplementary food, alongside the common cereals. This might help to alleviate the current food gap in the arid regions.

Tab. 6. Ash, crude protein (CP), fat (EE) contents (%) and gross energy (GE) in Mcal kg^{-1} DM of *P. turgidum* grains compared to some common cereals and to grain-producing species.

Species	Determined by	(%)			(Mcal/kgDM)
		Ash	CP	EE	GE
Panicum turgidum	Present study	18,1	10,92	7,31	4,01
Panicum antidotale	KEARL *et al.* (1979)	12,3	10,9	1,9	–
Panicum miliaceum		7,2	10,4	3,2	–
Echinochloa crusgalli		19,7	7,6	2,2	–
Zea mays		3,21	8,06	13,84	4,94
Triticum vulgare		4,73	9,5	8,69	4,63
Hordeum vulgare		4,38	9,92	2,02	4,13

The quality of forage can be expressed in several parameters, such as total digestible nutrients, digestible crude protein and caloric value (DUIVENBOODEN 1985). The total digestible nutrients (TDN) is an appropriate measure of the food energy available to animals only after the digestion losses have been deducted (LOFGREEN 1951). Therefore, TDN is a measure of energy requirement of animals and energy value of feeds (HENEIDY 2002). The mean value of TDN (64.03%; Tab. 7) of the grazeable parts of the studied wild *P. turgidum*

Tab. 7. The nutritive variables (DCP: digestible crude protein, TDN: Total digestible nutrients (%), GE: Gross energy, DE: Digestible energy and NE: Net energy in MJ kg^{-1} DM) of the studied wild *P. turgidum* populations compared to other related studies, rangelands, common fodder crops and to cultivated *P. turgidum*.

Panicum turgidum	Determined by	(%)		(MJ kg^{-1} DM)		
		DCP	**TDN**	**GE**	**DE**	**NE**
Mean of the studied wild populations	Present Study	2.73	64.03	17.6	11.79	5.02
Mean of cultivated populations		5.05	63.48	18.06	11.7	4.97
Gulf of Aqaba (Sinai)	HENEIDY (1996)	2.65	65.67	17.51	11.83	5.04
Rangelands (Western Mediterranean coastal region) EL Omayed	ABDEL-RAZIK *et al.* (1988a)	5.4	75	–	–	–
		4.9	72	15.09	10.91	4.77
Common fodder crops						
Barseem	SOLIMAN and EL-SHAZLY (1978)	–	56	–	–	–
Barley		–	64	–	–	–
Corn		–	68	–	–	–

populations was lower than that obtained by HENEIDY (1996). However, it meets the requirements for sheep diet (61.7%; NRC 1975) and breeding cattle diet (50.0%; NRC 1984). And it is higher than that of the common fodder crops (Barseem (clover) and barley, Tab. 7) recorded by SOLIMAN and EL-SHAZLY (1978). The TDN value of *P. turgidum* in the four studied phytogeographical regions can be considered fair for grazing animals compared with common fodder crops. The feeding value of forage depends primarily on the magnitude of its contribution to the energy need of an animal. Difference in this respect between forages is almost completely a consequence of the relative amounts in which they are voluntarily consumed (PETRUSEWICZ 1976). Energy contained in food is called gross energy (GE), energy intake or consumption. After subtracting the caloric value of the feces (F)

Tab. 8. Simple correlation coefficient between the soil parameters, the chemical composition (Ca/P, Ca/Mg, CF: % crude fiber and CP: % crude protein) and the nutritive variables (DCP: digestible crude protein, DE: digestible energy and ME: metabolized energy) of the aboveground parts of the studied wild *P. turgidum* populations; • significant, $P < 0.05$; •• very significant, $P < 0.01$; and ••• highly significant, $P < 0.001$.

Plant materials		Soil parameters							
		pH	**OM**	**$CaCO_3$**	**Silt**	**Mg**	**K**	**HCO_3**	**P**
Chemical composition	**Ca/P**	–0.31	**0.50•**	–0.08	**0.47•**	0.24	0.4	0.34	0.34
	Ca/Mg	**–0.5•**	0.15	–0.06	0.02	**0.45•**	**0.45•**	0.17	0.27
	CF	0.09	–0.03	**–0.74••**	–0.27	0.19	0.1	0.2	0.23
	CP	0.3	–0.24	0.4	0.04	–0.41	–0.4	**–0.51•**	–0.4
Nutritive variables	**DCP**	0.3	–0.24	0.4	0.04	–0.41	–0.4	**–0.51•**	–0.4
	DE	–0.09	0.15	–0.26	0.07	0.3	0.33	0.29	**0.46•**
	ME	–0.09	0.15	–0.26	0.07	0.3	0.33	0.29	**0.46•**

from the food energy and the losses through urine and methane, the reminder is called metabolized energy (ME) or assimilation energy (DRODZ 1975). The mean of gross energy (GE), digestible energy (DE) and the metabolized energy (ME) of the studied wild populations of *P. turgidum* (Tab. 7) was higher than mean of the natural forage in the western Mediterranean coastal rangelands (HENEIDY not published).

The principal components analysis (PCA) applied to the chemical composition and nutritive variables data of the studied *P. turgidum* populations showed that the first three vectors accounted for 92.7% of the total variance (14.98). The contribution of the investigated variables in the variation accounted for by the first three vectors was limited to a number of variables including ash, crude protein, carbohydrate contents (NFE), total digestible nutrients (TDN) and Ca/P ratio content of the plant materials (Tab. 9). PC1 expressed the greatest proportion of variation (42.8% of the total variance) with an eigenvalue of 6.41. It was related to ash, carbohydrate contents, organic matter, total digestible nutrients and Ca/P ratio content of the plant materials (Tab. 9). PC2 accounted for 32.8% of the variation with an eigenvalue of 4.91. It was related to crude protein, carbohydrate contents and Ca/P ratio content of the plant materials. PC3 accounted for 17.1% of the variation with an eigenvalue of 2.56. This PC corresponded to the crude protein, total carbohydrates, total digestible nutrients and Ca/P ratio content of the plant materials. When these three vectors were used as axes for the scatter diagram (Fig. 5) of the examined populations the same grouping was obtained as that of the cluster analysis of the *P. turgidum* studied populations using the chemical composition and nutritive variables data exemplified by the dendrogram resulting from the complete linkage method of sorting (Fig. 6). The studied populations were

Tab. 9. The loadings of the chemical composition and nutritive variables of the studied wild *P. turgidum* populations on the first three eigenvectors of the PCA analysis (*Values of the character with major contribution in the three vectors).

Character	Eigen vectors		
	PC1	PC2	PC3
Ash	***–0.50**	0.2	–0.21
CF	0.02	–0.02	–0.02
CP	0.05	***0.29**	***0.74**
EE	0.04	–0.036	–0.12
NFE	***0.39**	***–0.43**	***–0.39**
OM	***0.50**	–0.2	***0.21**
TDN	***0.34**	–0.1	***0.25**
DCP	0.02	0	0.01
GE	0.02	–0.01	0.01
DE	0.04	–0.03	–0.11
ME	0.02	0	0.01
NE	0.01	0	0.01
NR	0	0	0
Ca/Mg	0.02	0	0.02
Ca/P	***0.48**	***0.80**	***–0.36**

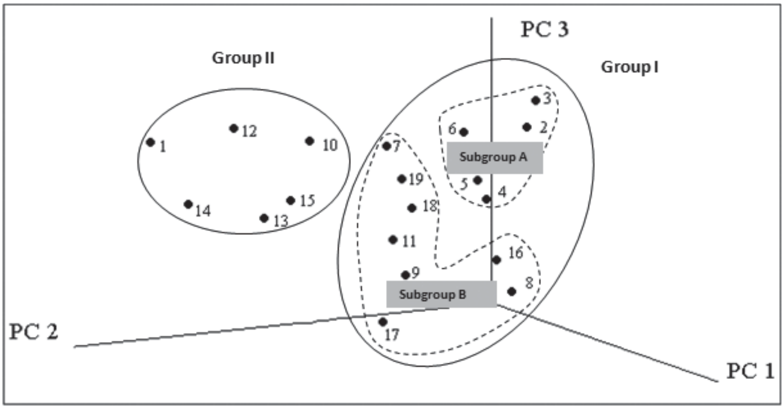

Fig. 5. Three-dimensional scatter plot of the first three eigenvectors of the PCA analysis based on data of chemical composition and nutritive variables of the studied wild *P. turgidum* populations. The solid line enclosed the main groups (I and II). The dashed line enclosed the two subgroups (A and B) differentiated within group I.

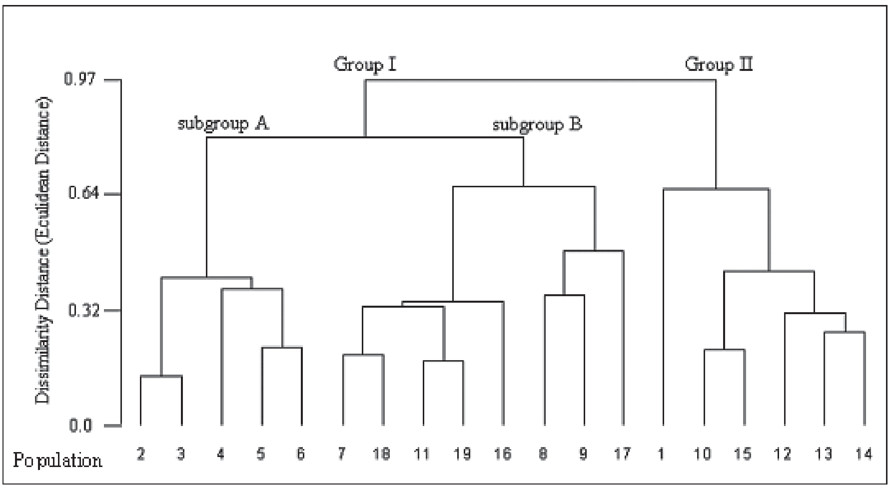

Fig. 6. Dendrogram resulted from application of complete linkage method of sorting, using chemical composition and nutritive variables of the studied wild *P. turgidum* populations.

separated into two main groups »I« and »II« at 0.97 dissimilarity distance. Group »I« included populations 2, 3, 4, 5, 6, 7, 8, 9, 11, 16, 17, 18 and 19, while group »II« included populations 1, 10, 12, 13, 14 and 15. Group »I« was split into two subgroups »A« and »B« at 0.81 dissimilarity distance. Subgroup »A« included populations 2, 3, 4, 5 and 6, while subgroup »B« included populations 7, 8, 9, 11, 16, 17, 18 and 19. The results obtained from applying both classification and ordination numerical analyses separated the studied wild *P. turgidum* populations into two major groups (I and II) on the basis of eight characters (the ash, crude fiber, crude protein, total carbohydrates, organic matter and digestible crude protein content and Ca/P ratio). While group »II« included six populations (five populations collected from south Sinai-Gulf of Aqaba coastal plain and one population from north Sinai) characterized by the lowest ash content, highest crude fiber, organic matter, total digestible nutrients content. Group »I« comprised the rest of the studied populations with relatively high nutritive value (higher protein, fat, carbohydrates and mineral content together with lower fiber content). Group »I« was further subdivided into two subgroups (»A« and »B«). Subgroup »B« was distinguished by having the highest values of carbohydrates, crude protein, digestible crude protein and energy content. Moreover it is characterized by low crude fiber contents and Ca/P ratio. This group included eight populations collected from Wady El-Natrun, Eastern desert, north Sinai and south Sinai. It is evident that subgroup »B« comprised populations posses the best nutritive characters concerning low fiber content, high crude protein, carbohydrates and ash content. The variation in the nutritive value among the studied populations may be attributed to the effect of some edaphic parameters. The variations in EC, organic matter content, calcium, potassium, bicarbonate, chloride, and phosphorous content of the soil were significant among the three groups (Tab. 10). It worth noting that, the variation in the nutritive value among the cultivated populations was insignificant. All the cultivated populations acquired high nutritive value, which indicate the effect of edaphic factors exerted on the wild population nutritive value as was illustrated also from the correlation between some edaphic factors and some nutritive variable.

Despite the variation in the edaphic, climatic and other factors such as grazing pressure factors among the studied phytogeographical regions, there was slight variation in the chemical composition and the nutritive variables of the studied populations, especially in the content of the organic constituents. However this did not significantly affect the nutritive value of the plant across the different studied populations. These relatively low varia-

Tab. 10. One way-ANOVA testing the significance of variation in the soil characteristics among the main groups resulting from the cluster analysis of the studied wild *P. turgidum* populations; •significant, $P < 0.05$; •• very significant, $P < 0.01$; and ••• highly significant, $P < 0.001$.

Soil characters		F-Value
EC (mmohs cm^{-1})		**4.5•**
pH		2.1
(%)	**OM**	**4.4•**
	Sand	3.2
	Silt	2.9
	Clay	2.2
	$CaCO_3$	3
(mg/100g)	**Ca**	**3.9•**
	Mg	0.3
	Na	3.5
	K	**8.4••**
	HCO_3	**7.3••**
	Cl	**4.0•**
	SO_4	1.0
	P	**11.2••**

tions in the nutritive value among the investigated populations indicate the considerable plasticity of the studied species to the environmental conditions. However, a notable difference was recorded between the wild and cultivated *P. turgidum* populations, in the chemical composition and the nutritive variables. The cultivated populations attained higher levels in crude protein, fats, carbohydrates, digestible crude protein and lower crude fiber content than the wild populations (Tab. 5 and 7). Based on the value of DCP and net energy, considering the scale suggested by BOUDET and RIVIERE (1968), *P. turgidum* has good or excellent forage quality.

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