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Full Length Research Paper

The effects of manure application and branch management methods on some agroecological aspects of summer squash (*Cucurbitapepo* L.) in a low input cropping system

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Squash (*Cucurbitapepo* L.) is an important oil seed and medicinal plant which produces unsaturated fatty acids, cosmetic medicine and health products. In order to study the effects of different cattle manure levels and branch management methods on organic production of Summer squash, two field experiments were conducted during years 2005 and 2006. Treatments consisted of four manure levels (10, 15, 20, 25 t ha^{-1}) and two branch management methods (with and without wood pole), which were allocated to main plots and subplots, respectively. Results showed that branch management method without wood pole was more efficient than with wood pole. Increasing manure level had significant effect on fruit and seed yields; however, these traits were not significantly affected by manure levels residual effect at the second year. There were no differences in the number of seeds per plant due to manure levels in either year. Seed oil content slightly increased when manure level increased from 10 to 25 t ha^{-1}. This researchindicated that application of 20 t ha^{-1} cattle manure with no-chemical fertilizer is an appropriate method for organic production of Summer squash which produce greater yield with high seed oil contents.

Key words: Pumpkin, Schneider squash, manure, seed oil, yield, organic production.

INTODUCTION

In recent years, safety and health of food is becoming a major concern due to negative impacts of over use of chemicals for human health and environment (Gliessman, 1998; Pimentel et al., 2005). Furthermore, using colorant and chemical food additives seriously threatened aspects of safety in food processing. In this context, applying natural food and plant products including medicinal plants is gaining significance. On the other hand, cultivation of medicinal and other food plants with medicinal properties has been expanded (Berenyi, 1998). One of such causes is the production of oil seeds with unsaturated fatty acids such as oleic and linoleic acids (Khan et al., 1987; Murkovic et al., 1996). Those unsaturated fatty acids which cannot be synthesised by human and animal organisms are known as essential fatty acids (Balatincz, 2000).

Pumpkin, *Cucurbitapepo* L., (English name; summer pumpkin) is an herbaceous, monoecious, annual plant of the cucurbitaceae family (Bombardelli and Morzzoni, 1997). This species includes plants with a prostrate stem. Seeds are coatless with a thousand weight of 200 to 210 g (Bombardelli and Morzzoni, 1997). Pumpkin seeds have been used in traditional medicine as a vermifuge, and are among several food plants and herbs containing fatty acids and phytosterols that are used for the treatment of Benign Prostatic Hyperplasia (BPH) (Dvorkin and Song, 2002; Younis et al., 2000). *Cucurbitapepo* is an important oil seed plant which is used in food and also

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in cosmetics and health products (Balatincz, 2000; Bombardelli and Morzzoni, 1997; Murkovic et al., 1996). In commercial production of pumpkin seed oil, is employed primarily because hull-less variety exist for which processing of the raw seeds is simplified (Wendy et al., 2006). Some medicines made from seeds of this plant are Peponen®, Graunfink®, Prostaliquid®, Phosphostrol®, Pepostrin® and Kurbiskern® (Bombardelli and Morzzoni, 1997; Murkovic et al., 1996; Younis et al., 2000). Active ingredients of the seed are fatty acids, vitamin E and phytosterols (ß-sitosterol). The most important nutritive agents of the pumpkin seed are the fatty acids (Balatincz, 2000). Wendy et al. (2006) and Balatincz (2000) reported that the major components (96.58 up to 98.76 %) of *C. pepo*oil are linoleic, oleic, palmitic and stearic acids. However, the fatty acids content could be varied depending on environmental conditions and management practices. Murkovic et al. (1996) reported that seeds of some *C. pepo* species contained 39.5 to 56.5% oil with 21 to 67.4% linoleic acid. They also noted that delaying the harvest of fruits and a decrease in temperature at maturity caused these constituents to increase. Younis et al. (2000) found that the four dominant fatty acids were: palmitic C16:0 (13.3%), stearic C18:0 (8.0%), oleic C18:1 (29.0%) and linoleic C18:2 (47.0%). Wendy et al. (2006) found that, there is considerable intra-specific diversity in fatty acid profiles. Berenyi (1998) found that small fruits of *C. pepo*are suitable for oil production and large fruits for other purposes including seed production or cattle feed.

The cropping of medicinal plants could positively contribute to the income of organic farms as the guidelines for good agricultural practice for medicinal and spice plants demands products which are not contaminated by chemicals (Europam, 1998). The requirements with view to homogeneity and quality, particularly the content of bioactive components are continuously increasing so that adequate crop-specific growth conditions need to be elaborated. Growth conditions such as temperature, light intensity and species (Griffe et al., 2003; Weiss, 2000), nutritional factors like nitrogen and sulfur supply influencing the content of bio-active components (Bloem et al., 2001a and 2001b). Growers use a wide variety of practices to maintain or improve soil health in crop production systems. These practices generally are part of long-term, site-specific management programs that aim at developing fertile and biologically active soils that readily capture and store water and nutrients, have good tilth and suppress plant diseases (Ghorbani et al, 2008).

Indeed, there is a fundamental lack of knowledge about many plant species and their cropping practices particularly in developing countries (Koocheki et al., 2008). It is also true for organic fertilization and crop management in squash production. Therefore, the present studies were carried out to find out the effects of organic soil and crop managements on quantity and quality of summer squash seeds.

MATERIALS AND METHODS

General information and experimental design

This study was conducted during the two growing seasons of 2005 and 2006 in the Research Farm of Faculty of Agriculture, Ferdowsi University of Mashhad, Iran, located on North latitude of 36°, 15' and East longitude of 59°, 28' with 985 m altitude above sea level. The experiment was arranged as split plot based on randomized complete block design with three replications. Four cattle manure levels (10, 15, 20, 25 t ha^{-1}) were assigned to the main plots. Branch management methods, 1) with wood pole, 2) without wood pole (as control) were allocated to the subplots. The manure levels were considered based on nitrogen content of manure and recommended amount of chemical fertilizers in conventional systems (150 to 200 kg ha^{-1} nitrogen) under Mashhad conditions. A month before planting in year 2005 all amounts of manure levels were applied and mixed with soil. At the second year of experiment, all operations were done as same as the first year, but no manure was applied. Main plots and subplots dimensions were 9 × 7 m, 9 × 3.5 m, respectively.

Soil and manure analysis

The field soil has been classified in the Aridisol order with dominant suborder as Calcids according to USDA 2010 keys for soil taxonomy (USDA, 2010). The soil texture was sandy clay loam. Nutrient contents of manure used were 2.11, 0.73, and 1.88% N, P and K, respectively (Table 1).

Planting and management

At the first year of experiment, a deep moldboard plowing was applied in the whole trial field in autumn and the land was disked to be prepared for planting in spring. At the second year, no soil tillage was conducted for bed preparation and planting practices, only planting holes were digged by scuffle hoe and seeds were planted on the same place as the first year. Seeds of squash were sown on April 20, 2005 and April 15, 2006 on rows 3 m apart with a distance of 50 cm between each plant on rows.

No chemical fertilizers or biocides were applied and weeds were controlled by hand. Plants were irrigated via raceways every 8 days during the growing season. Wood poles were placed adjacent to each plant and plants were established on the poles fixed with cotton rope in plots with wood pole. Based on the results of the first year in which superiority of plants without wood pole was

Table 1. Soil properties of the experimental field.

	Soil depth (cm)			
	0-15		15-30	
	Year 2005	Year 2006	Year 2005	Year 2006
Total N (%)	0.077	0.081	0.068	0.073
Available P (ppm)	45	38	41	35
Available K (ppm)	480	473	465	459
C/N	13.2	12	12.5	11.3
pH (saturation extract)	7.8	7.3	7.6	7.1
Organic C (%)	0.58	0.74	0.52	0.69
Water storage capacity (%)	24.3	27	22	25
Bulk density (g cm^{-3})	1.42	1.33	1.54	1.47

confirmed, this treatment was not conducted at the second year of experiment. Therefore, at the second year of experiment, only the effect of manure was investigated and the experimental data were analyzed with levels of manure only.

Measurements

In both years, when the fruits color turned to yellow, there were collected and measurements were made on fruits and seeds including fruit yield, seed yield, seed oil and protein contents. The seed oil content was determined by treating the weighed powdered seeds with n-hexane and refluxed for 12 h in a Soxhlet extractor. The solvent was removed by rotary evaporator. The oil sample was then placed in a vacuum oven kept at 60°C for 30 min, then accurately weighed and oil percentage was determined in three samples per treatments (Jahan et al., 2012a).

Total protein content of the defatted seeds was determined by the Macro Kjeldahl method using a kjeldahl analyzer, Kjeltec system Model 8100, FOSS Ltd. in three samples per treatment and the result multiplied by 6.25 to give crude protein (FAO, 2012).

Statistical method and analysis

To approve the normal distribution of data, a normality test was carried out and then data was analyzed by analysis of variance (ANOVA) and regression, using Minitab statistical software Ver. 14. Then means were compared by using Duncan's multiple range test at 0.05 probability level.

RESULTS AND DISCUSSION

Effects of manure application and its residual effect on fruit and seed yield

Results of combined analysis of the experimental data for two years (without wood pole) showed that the effect of manure application on fresh fruit yield was significant; however, manure application did not affect seed dry weight and seed number (data not shown).

An increasing trend was observed in fruit fresh yields with increasing the level of cattle manure up to 25 t ha^{-1} (Figure 1). Application of cattle manure at a rate of 10 to 20 t ha^{-1} resulted in a significant increase in fresh fruit yield; however there were no significant differences between 10 and 15 t ha^{-1}. In general, the effect of cattle manure levels was somehow inconsistent and a reduction of yield at 25 t ha^{-1} seemed unusual. It might be postulated that the effect of cattle manure on this species is achieved up to 20 t ha^{-1} and further increase may have a detrimental effect possibly due to plants die off. It could also be assumed that higher levels of cattle manure might have caused water storage in the root zone and hence help to spread root pathogens. Bacci et al. (2006) showed that for the spring–summer crop cycle, the rainfall was the main cause of plant mortality during vegetative stage due to excessive soil water, and stems bored by *Diaphania*spp. In the present study also visual assessment showed that more dead plants observed at the highest manure level (25 t ha^{-1}).

Gholipoori (2006) and Berenyi (1998) indicated that a well-drained soil is suitable for this plant species. This could be an indication of sensitivity of plants to high levels of water in the root zone. On the other hand, Aruyi et al. (2000) reported that application of high level of nitrogen fertilizers caused fresh vegetative growth and hence low yield of fruit. Therefore, having low yield at 25 t ha^{-1} of cattle manure could be associated with higher water level in the root zone and also availability of more nitrogen which changes the proportion of vegetative to generative growth.

With increasing cattle manure level from 10 to 20 t ha^{-1} at the first year, seed yield increased but there was no further increase by increasing the level of manure to 25 t ha^{-1} (Figure 2). At the second year, seed yield increased 200 percent compared to the first year, but there were no significant differences between seed yield concerning to residual effect of different manure levels (Figure 2). The

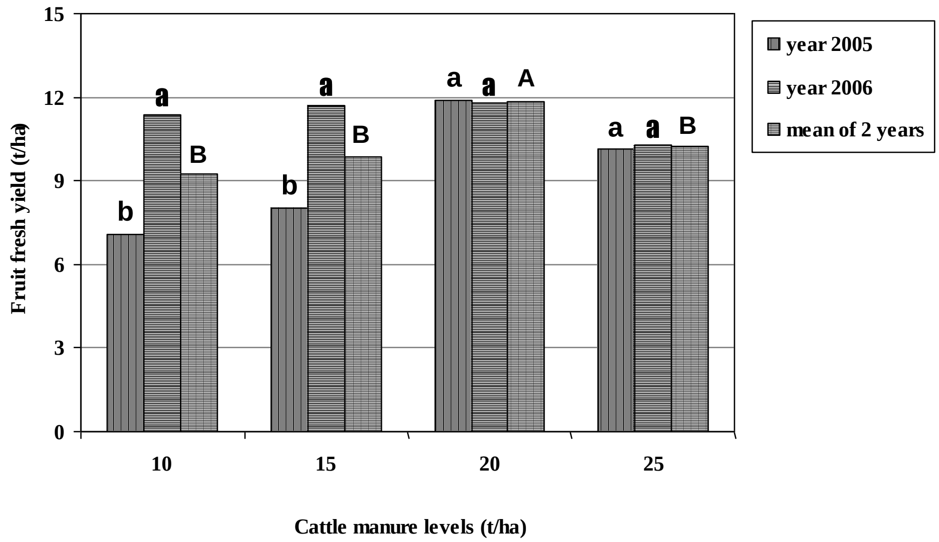

Figure 1. Effect of cattle manure levels on *C. pepo* fresh fruit yield. In each year, different letters indicate significant difference (p≤0.05).

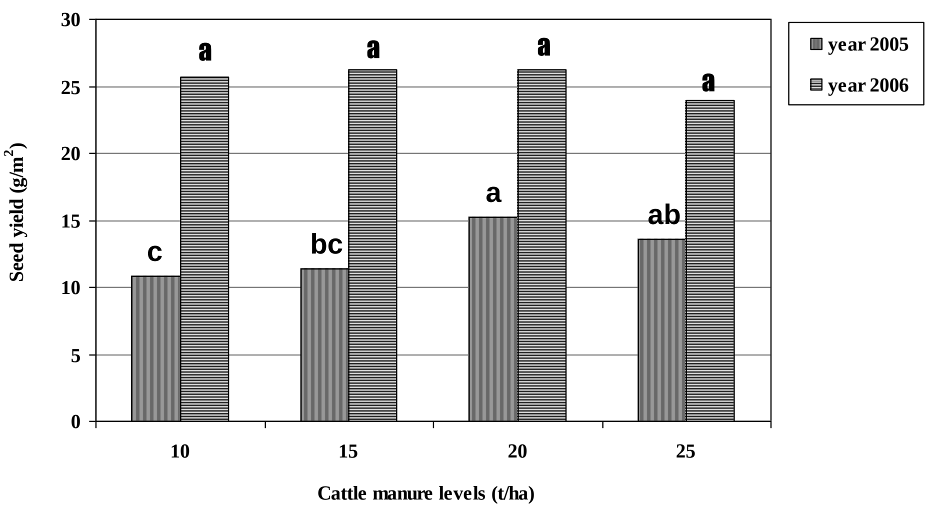

Figure 2. Effects of cattle manure levels on *C. pepo* seed yield. In each year, different letters indicate significant differences (p≤0.05).

residual effect of manure concerned to seed yield was more revealed than of the fruit yield (Figures 1 and 2).

In general, the response of both fruits and seed yields to residual effect of cattle manure levels were higher at the second year compared to manure application at the first year.

These results could probably be due to releasing more nutrients in the second year from the manures used in the first year (Lampkin, 1999). Mader et al. (2002) cautions against heavy applications of animal manure at the beginning of the conversion because the biological activity in the soil may be inadequate for timely breaking down of the organic materials.

Effects of manure application on seed and fruit characteristics relationship

Seed yield increased almost linearly with increasing fruits fresh yield, However, it was levelled off above a fruit yield of 12 t ha^{-1}(Figure 3a).

Therefore, maximum seed yield was obtained at manure levels lower than the application rates needed for the highest fruit yield. The relationship between individual fruit weight and seed weight per fruit (Figure 3b) showed that *C. pepo* could be a sink-limited plant during grain filling period as seed weight no longer increased in larger fruits.

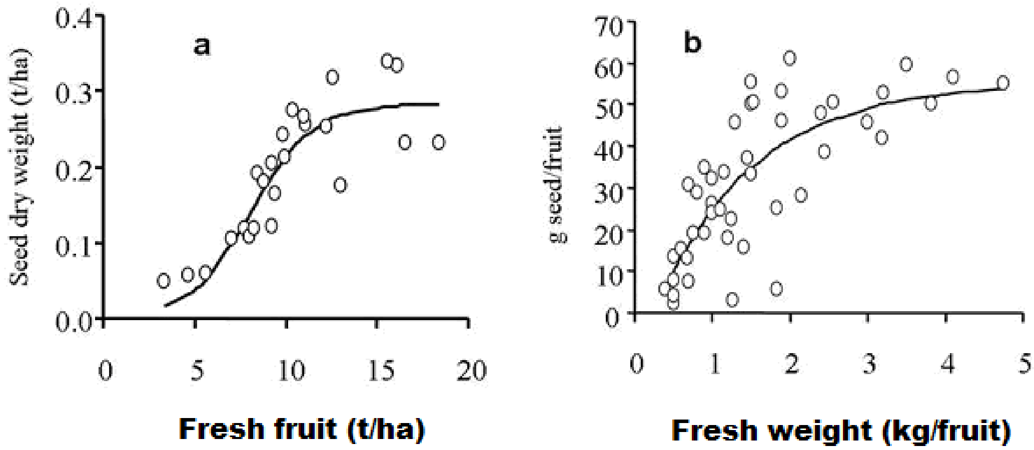

Figure 3. Relation between fruit fresh yield and seed yield (a) and individual fruit weight and seed weight per fruit (b) in *C. pepo*.

Table 2. Means number of healthy fruits, individual fruit weight, number of seed per fruit and thousand seed weight of *C. pepo* as a result of manure application in year 2005.

	Measured traits	Cattle manure levels (t ha^{-1})				Means
		10	15	20	25	
First year (2005)	Number of healthy fruits per hectare	3333^{B}	3174^{B}	4444^{A}	3809^{B}	3690
	Fruit weight (kg/fruit)	1.6^{A}	1.6^{A}	1.5^{A}	2^{A}	1.67
	Number of seeds per one fruit	268^{A}	301^{A}	293^{A}	291^{A}	288
	1000 seeds weight (g)	121^{A}	116^{A}	117^{A}	122^{A}	119

In each row, different letters indicate significant difference (p≤0.05).

Table 3. Means number of healthy fruits, individual fruit weight, number of seed per fruit and thousand seed weight of *C. pepo* in year 2006 as a result of residual effect of manure application in year 2005.

	Measured traits	Cattle manure levels (t ha^{-1})				Means
		10	15	20	25	
Second year(2006)	Number of healthy fruits per hectare	3174^{B}	3968^{A}	4285^{A}	3015^{B}	3603
	Fruit weight (kg/fruit)	0.9^{A}	1.4^{A}	1^{A}	1.4^{A}	1.17
	Number of seeds per one fruit	623^{A}	520^{A}	497^{A}	619^{A}	564.7
	1000 seeds weight (g)	127^{A}	125^{A}	121^{A}	128^{A}	125

In each row, different letters indicate significant difference (p≤0.05).

Effects of manure application and its residual effect on fruit characteristic

Year 2005

The number of healthy fruits per hectare was affected by manure rates as it was the highest at 20 t ha^{-1} manure, compared with other levels (Table 2). As expected this trend was also observed for fresh fruit yield (Figure 1). Number of seeds per fruit and also thousand seed weight were not affected by manure application rates (Table 2).

Year 2006

The highest number of healthy fruits per hectare was related to residual effect of 15 and 20 t ha^{-1} manure levels; moreover, there was no difference between 10 and 25 t ha^{-1} residual effect of manure levels (Table 3). Number of seeds per fruit and thousand seed weight were not affected by the residual effect of all manure

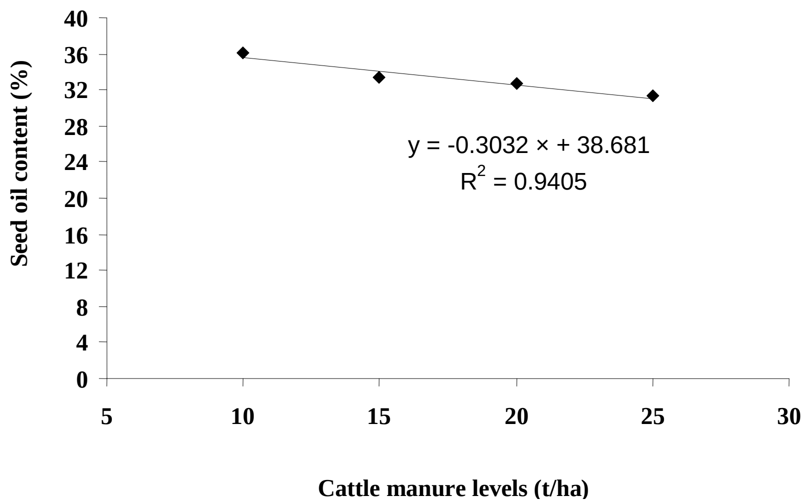

Figure 4. Effect of cattle manure levels on seed oil content.

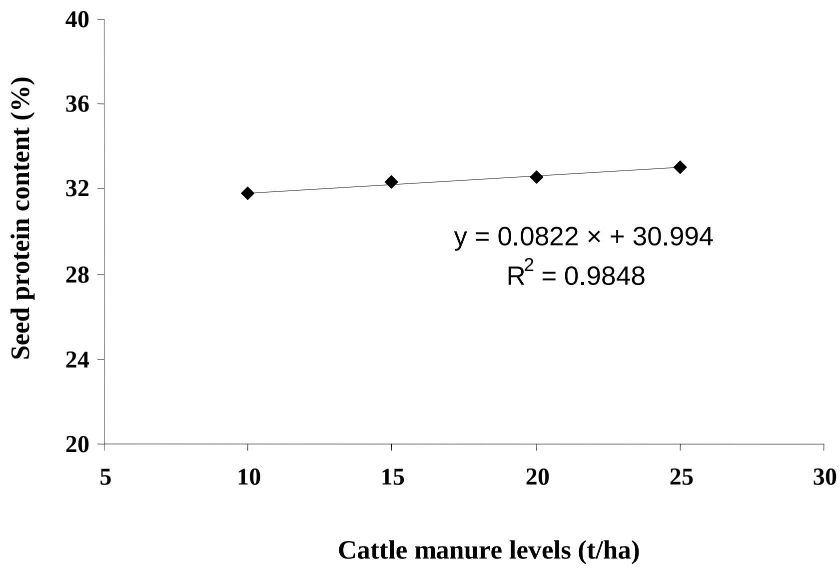

Figure 5. Effect of cattle manure levels on seed protein content.

application rates (Table 3).

There are reports indicating that at the first year of application, only 50% of nutrients for cattle manure is available for the plants (Kuepper, 2000; Lampkin, 1999). Therefore, it might be concluded that changing in seed yield associated with manure application and its residual effect was mainly due to the number of fruits per hectare rather than other yield components.

Effects of manure application on seed oil and protein content

Increasing the cattle manure rates resulted in a decrease in oil percent (Figure 4). Such reduction in seeds oil content was estimated by 5% when cattle manure was applied at a rate of 10 to 25 t ha^{-1}. These results are in agreement with those obtained by Aruyi et al. (2000). Reports (Jahan et al., 2012b; El-Habbasha et al. 2007; Weiss, 2000) indicate that application of nitrogen fertilizers decrease oil content of oilseed crops.

Seed protein content increased by increasing the cattle manure rates from 10 to 25 t ha^{-1} (Figure 5), such increase in seed protein may be due to increasing nitrogen fertilization which was reported by Jahan et al. (2012b), Sinclair et al. (2003) and Kimball et al. (2001).

Effects of branch management on fruit fresh yield

Fruit fresh yield in branch management without wood pole (control) was higher than the treatment with wood

Table 4. *Cucurbita pepo* fruit fresh yield (kg ha^{-1}) resulted from branch management method and four cattle manure levels application.

Branch management method	Cattle manure levels (t ha^{-1})				Mean
	10	15	20	25	
with wood pole	6711^{B}	7587^{B}	10885^{A}	7841^{B}	8256^{B}
without wood pole	7483^{B}	8479^{B}	12879^{A}	12463^{A}	10315^{A}
Mean	7074^{C}	8033^{BC}	11882^{A}	10152^{B}	

Means followed by the same letter, do not differ significantly at $p \leq 0.05$.

pole at all levels of cattle manure (Table 4). It was true for seed quantity and quality too. It seems that when a branch of plant is arranged on the pole and ropes between the poles, the hang fruit are more susceptible to wind and hence intorsion of stem resulted to impaction and cutting of stems.

Conclusion

Fruit and seed yields of summer squash increased with applying higher rates of cattle manure up to 20 t ha^{-1}, however, further increase in cattle manure did not produce any higher yield. Therefore, an optimum amount of cattle manure seems to be 20 t ha^{-1}. The fertility benefits of cattle manure application as the residual effect was observed at the second year resulted to higher measured traits; however, conducting no wood pole possibly interfered. This study showed that application of wood pole is not a recommendable practice for summer squash production.

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