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THE PROXIMATE AND CHEMICAL COMPOSITION OF IMPROVED CHICKPEA CULTIVARS GROWN UNDER THE PURE STAND AND BANANA INTERCROP SYSTEMS IN SOUTH WESTERN UGANDA AGRO ECOLOGICAL ZONE

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ABSTRACT

South Western Uganda Agro ecological Zone is a major banana producing region faced with malnutrition, partly due to high intake of banana, which is low in protein, essential amino acids and most micronutrients compared to other foodstuffs with high protein and micronutrients. Five improved chickpea cultivars (ICCV 00108, 1CCV 00305, 1CCV 92318, 1CCV 96329, 1CCV 97105), introduced as an alternative protein source were grown as monocrop and intercrop with bananas and the effect of the cropping method on their nutritive value investigated. Their proximate and chemical compositions were determined, using standard methods. Moisture content ranged between 11.11 and 12.14 %, crude protein content ranged between 18.00 to 19.04 %, crude fat content varied from 3.29 to 4.69 %, ash content ranged between 3.38 and 12.14 %; whereas crude fibre ranged between 4.43 and 11.20 %. The Fe content varied from 15.98 to 31.19 mg/100g, Zn ranged between 248.42 and 292.18 mg/100g, Cu varied between 12.91 and 25.95 mg/100g, whereas Mn varied from 84.82 to 112.1 mg/100g. The K content ranged from 855.00 to 1060 mg/100g, Na ranged from 269.17 to 590.00 mg/100g, Mg varied from 85.84 to 95.84 mg/100g, Ca ranged between 464.17 and 507.50 mg/100g whereas P varied between 366.67 and 418.34 mg/100g. The cropping method did not affect the proximate composition of the chickpea but the crude fibre and ash contents varied significantly ($P<0.05$) among the cultivars. All the mineral contents except P, varied significantly ($P<0.05$) among cultivars. The cropping method significantly ($P<0.05$) affected all mineral contents except Ca, Cu and P. Cultivar ICCV 97105 was more nutrient-dense, compared to other cultivars. The results indicate differences in the seed ash and crude fibre contents of the cultivars studied. The findings of this study establish the five analysed chickpea cultivars as a potential source of protein and appreciable amounts of both trace elements (Fe, Zn, Cu, Mn) and macro-elements such as K, P, Mg and Ca.

Key words: Proximate, Chemical composition**,** Malnutrition, Protein**,** Chickpea cultivars, cropping method

INTRODUCTION

South Western Uganda Agro ecological Zone (SWAEZ) is a major banana producing region of Uganda faced with inter-related challenges of food insecurity, poverty and malnutrition resulting from consumption of inadequate and low nutrient foods [1]. Malnutrition is also partly attributed to high intake of banana (with diet shares between 54 and 69 percent), which contains inadequate protein, essential amino acids and most micronutrients compared to high protein foods [2]. It is further compounded by limited access to animal sources of protein, forcing the resource-poor households to look for cheaper foods, in order to fit their household budgets. Malnutrition is mainly manifested among children, pregnant women and persons living with HIV and AIDS. Severe acute malnutrition (SAM) is particularly high, with the prevalence rate of stunting among children under five years of age at 49.6 % [3].

Conventional legumes such as beans, supply proteins in the diets of many resource-poor households, but their production still remains insufficient and is too commercialised [4]. To improve food and nutrition security as well as household incomes in the region, five (ICCV 96329, ICCV 00305, ICCV 97105, ICCV 92318 and ICCV 00108) high yielding and stress tolerant chickpea cultivars were introduced. Chickpeas, which are still an under-utilised legume in the region, have high potential for improving the quality of the diets because of their high nutritive value.

Chickpea (*Cicer arietinum* L.) belongs to the legume family and is a major source of dietary nutrients for many people, especially in developing countries [5]. It contains high protein (19.0 %), carbohydrate (61.0 %) and fibre (17.0 %) contents. The legume also provides the body with all the essential amino acids for humans except sulphur-containing amino acids, which can be complemented by adding cereals to the daily diet [5].

Its protein quality is considered to be better than other pulses, with its protein hydrolysates being potential bioactive ingredients. It is a good source of minerals especially potassium and contains important vitamins such as riboflavin, niacin, thiamin, folate and the vitamin A precursor, β-carotene [5]. Chickpea also has desirable agronomic advantages like fixing nitrogen in amounts of 140 kg N ha^{-1}, which improves soil fertility, benefits intercrops and subsequent crops, hence increasing their yields and saving fertilizer costs [6]. It is a drought-tolerant crop that can potentially contribute to household income and food security in the banana farming system. It is less labour-intensive and its production demands low external inputs compared to cereals. But like other legumes, chickpea contains anti-nutritional factors which impose a restriction on its consumption. In the previous studies, chickpea whole seeds have been found to contain 9 to 31 mg/g (dry weight basis) of trypsin inhibitors [7], 740-763 mg/100 g (dry weight basis) of tannin and 138-171 mg/100 g of phytate (dry weight basis) [8].

In the last decade, there has been an increased grower interest in using intercropping, because it results in enhanced ecosystem productivity *vis-à-vis* environment-friendly management of pests [9], effective use of available resources and efficient use of labour, erosion control and food security. Other advantages of intercropping are efficient use of labour and food security as it provides insurance against crop failure or against unstable market prices for a given commodity, especially in areas subject to extreme weather conditions such as drought and flood. But, crop variety or cultivar performance varies under different management regimes. Therefore, in spite of the good nutritional profile as well as desirable agronomic characteristics of chickpea, its chemical composition and therefore its nutritive value is subject to fluctuations. These variations can be either due to intrinsic or extrinsic factors. To maximise land productivity and allow biodiversity in the management of pests and diseases, farmers in SWAEZ grow the crop with banana intercrop. Elsewhere, chickpea is frequently grown as a sole plant or intercropped with other plants, especially cereals but the focus has been on its agronomic performance and yield, and no reports are available on the effect of the cropping method on its seed nutrient composition and therefore its nutritive value. Besides, the proximate composition and mineral element content of the introduced cultivars are not known. The objective of this study therefore, was to determine the proximate and chemical composition of the introduced chickpea cultivars, as affected by the cropping method in the SWAEZ.

MATERIALS AND METHODS

Sample collection

Chickpea seeds of the five improved cultivars (ICCV 00108, 1CCV 00305, 1CCV 92318, 1CCV 96329 and 1CCV 97105) collected from 96 farmers' fields (of the major soil types and similar environmental conditions as classified by farmers, community development facilitators and local leaders) hosting the experiment as monocrop or intercrop with banana were used as replicates in unbalanced treatment structure. The fields are located in Birere and Masha sub counties of Isingiro district in South Western Uganda, at $0^o42'.01''$ N, latitude, $30^o41'.78''$ E longitude and altitude range of 1367-1419 m above sea level [10]. The experiments were managed by farmers with support from the research team. All experiments were kept weed and pest free by regular hand hoeing and pesticide application when needed. At maturity, all cultivars were harvested, sun-dried and threshed.

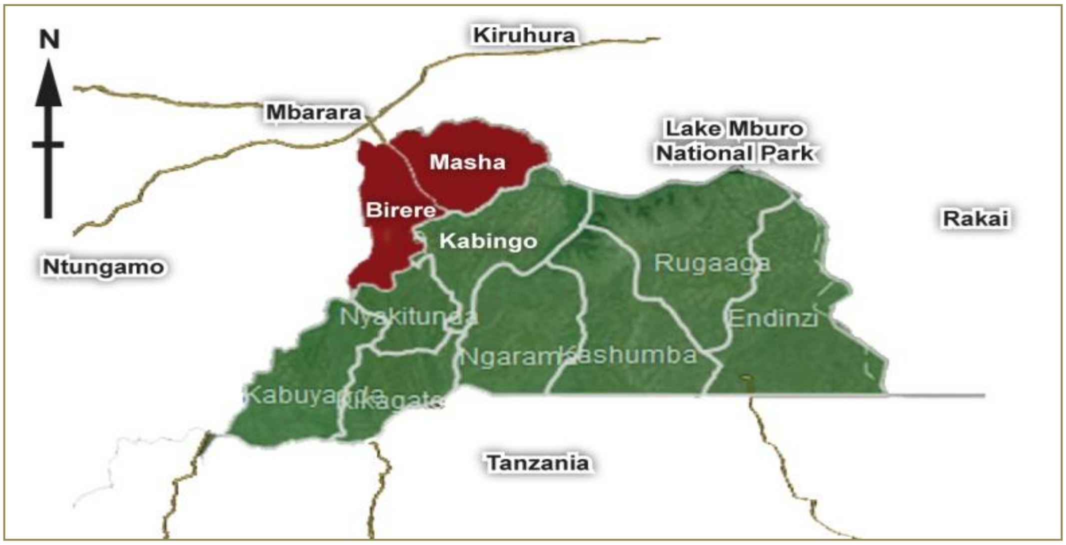

Figure 1: A map of Isingiro district showing (in red) Masha and Birere sub counties

Sample preparation

The seeds for each cultivar were manually sorted to remove the split, wrinkled and mouldy ones, and foreign materials; ground with an electric grinder to pass through a 0.425 mm sieve, a size suitable for proximate and chemical composition analysis; and then stored in screw tight containers until required for analysis.

Chemicals and reagents

All chemicals and reagents used were purchased from BDH Chemicals - Kampala and were of analytical grade.

Proximate composition analysis

Moisture content, total ash, crude protein (N × 6.25), crude fibre and crude fat of the seed flours were determined according to AOAC (2000), using the official methods 925.09, 923.03, 979.09, 962.09 and 4.5.01 respectively [11]. Moisture content was determined based on weight loss after oven-drying at 105° C for 3 hours. Ash was determined by incineration of known weights of the chickpea flour samples in a muffle furnace at 550° C (Gallenkamp, size 3) for 6 hours. Total nitrogen was measured using the Kjeldahl method and protein content was calculated as N × 6.25. Crude fibre was determined after digesting the chickpea flour samples by refluxing 1.25 % boiling sulphuric acid and 28 % boiling potassium hydroxide. In proximate analysis, the crude fibre represents the insoluble carbohydrate while the Nitrogen Free Extractives (NFE) represents the soluble components, which together form the total carbohydrate of a food material. Crude fat was determined by exhaustively extracting a known weight of flour sample in diethyl ether (boiling point, 55 °C) in a Soxhlet extractor and the ether evaporated from the extraction flask [11]. All the assays were performed in triplicate and the results were expressed as a percentage of total dry matter of the chickpea flour sample.

Chemical composition analysis

Minerals were determined after wet ashing by concentrated nitric acid and perchloric acid (1:1, v/v). Minerals: copper (Cu), magnesium (Mg), manganese (Mn), iron (Fe), zinc (Zn) and phosphorus (P) were determined according to the method of AOAC (2000) [12], using Atomic Absorption Spectrophotometer (Perkin-Elmer, Model 2380, USA). The flame photometer (Corning 410, England) was applied for calcium (Ca), potassium (K) and sodium (Na) determination, according to the method described by James (1995) [12]. All values were expressed in mg/100g of chickpea flour sample.

Statistical analysis

The analysis was carried out in triplicates for all determinations. The data generated were subjected to analysis of variance (ANOVA) using Statistical Analysis Systems version 9.1 SAS (2003) software package. A multiple comparison procedure of the treatment means was then performed, following the Duncan's multiple range test (DMRT) [13]. Significance was defined at $p<0.05$.

RESULTS

Proximate composition

Results for proximate composition of the cultivars used in the study are presented in Table 1. The proximate composition ranged between 11.11-12.14 % for moisture, 18.00-19.04 % for crude protein, 3.29-4.69 % for crude fat, 3.38-12.14 % for ash while crude fibre content ranged between 4.43-11.20 % of dry matter (DM). The data indicate that the Proximate composition levels of moisture, crude protein and crude fat did not significantly differ ($P<0.05$) but the ash and crude fibre composition varied among the chickpea cultivars. The ash content in ICCV 97105 was significantly higher (12.14±0.21) than in cultivars ICCV 00108, 00305, 92318 and 96329. The crude fibre content was also significantly higher in cultivars ICCV 00108 (10.41±2.17) and 97105 (11.20±0.88) than that recorded in the rest of the cultivars. Analysis of variance indicated that the cropping method did not significantly affect the content of all the proximate parameters analysed (Table 2).

Chemical composition

Table 3 presents data on chemical composition (mg/100g of DM) of the cultivars used in the study. The Fe content ranged between 15.98-31.19 mg/100g, Zn content ranged between 248.42-292.18 mg/100g, Cu was between 12.91-25.95 mg/100g and Mn was between 84.82-112.1 mg/100g. The K content was between 855-1060 mg/100g, Na was between 269.17-590 mg/100g, Mg was between 85.84-95.84 mg/100g, Ca was between 464.17-507.5 mg/100g, and P was between 366.67- 418.34 mg/100g.

Among the cultivars, mineral content varied significantly for all parameters except P. Cultivar ICCV 97105 had the highest (418.34 mg/100g) content of P while ICCV 96329 had the highest content (1060.00 mg/100g and 590.00 mg/100g) of K and Na respectively. Analysis of variance however revealed that the chemical content of all minerals except Ca, Cu and P was affected by the cropping method (Table 4). The pure stands of chickpea generally had higher content of all the analysed chemical elements except Na and Mn, than the intercropped chickpea.

DISCUSSION

The differences observed in the proximate composition between the cultivars in the present study can be attributed to inherited (genetic) differences (for ash and crude fibre) and cropping method effects (for chemical composition). Environmental conditions are known to exert significant influences on chemical composition of legumes [14]. Elsewhere, significant genetic variations in chemical composition of legume seeds have also been reported [15].

There are several physical (example, competition) mechanisms by which certain crops affect the nutrient content of others when intercropped. The effect of the cropping methods on the content of certain minerals in chickpea in the present study could possibly be due to competition and stress, resulting from the banana and chickpea roots competing for those particular minerals in the soil. Allelopathic effects on roots have also been reported elsewhere and may vary in intensity from subtle to startling, depending upon the nature of the receiving plant and the physiological/metabolic processes that are influenced [16]. Amongst several processes susceptible to allelopathic influences, which could significantly hamper root growth and physiological activity, is the decrease in cell water potential [17]. In the present study, the roots of chickpea could have had a significant reduction in tissue water concentration due to the companion crop (banana), subjecting it to stresses like salinity and drought. Such stress has also been reported in an earlier study [18]. Therefore, such effects may have affected the ability of chickpea roots to take up some minerals from the soil, thus affecting the nutritional quality of the chickpea seed. Except for P, the effect of the cropping method on the Ca and Cu content is not yet fully understood. Consistent with a previous study [18], no significant difference was observed in the P content of monocropped and intercropped chickpea cultivars. This can be partly attributed to the fact that legumes secrete more acid phosphatases in the rhizosphere than other crops, often leading to greater enzyme activity and increased P availability [19].

The results further indicate that, the maximum and minimum moisture content observed in the chickpea cultivars was 12.14±0.21 and 11.11±0.97 % respectively. The moisture content of all the cultivars analysed falls within the recommended range of 0-13 %, suitable for storage and processing without microorganism degradation of the triglyceride. It was however slightly higher than that reported elsewhere [20]. The variation of moisture content may be attributed to a variation in the drying temperatures. Moisture content is an integral part of the proximate composition analysis of any food material in order to determine its stability, and achieving a dry state of flours is of utmost importance for their shelf stability. At low moisture levels, any food possesses low water activity hindering any microbial growth. Moreover, dry flours are devoid of moisture required for the spore growth and physiological activity.

The data show that Chickpea is a valuable source of protein. The observed protein content (17.32-19.47 %, dry weight basis) is in the same range as that reported (17.62±0.9) in a previous study [21]. It is also much higher than that of cereals (wheat and maize), and comparable to other legumes and can therefore provide an alternative source of protein to the resource-poor households. Nevertheless, the crude fat (3.29±0.04-4.69±1.02) content does not qualify these chickpea cultivars as oil rich, especially when compared with other legumes like groundnuts and soybeans [22]. The crude fibre content (4.43-11.20 %) observed in the current study was higher than that (3.82) recorded in the previous study [22]. The crude fibre content depends on the thickness of the seed coat, because it is present mainly in the outer seed testa. It was higher in cultivars ICCV 00108 (10.41±2.17) and 97105 (11.20±0.88) which were of the *Desi* type, characterized by a thick and rough seed coat, than that recorded in the rest of the cultivars (Table 1). Legume plants get minerals from their soil environment and deposit them to their seeds, and in turn use them for plant growth and development. These minerals collectively contribute towards the ash fraction of the seed. All mineral contents, except K and Mg in the analysed chickpea cultivars were higher than those reported elsewhere [23]. The high (3.05-12.14 %) content of ash suggests that chickpea contains appreciable amounts of mineral elements and if processed well to reduce the amount of antinutrients, its regular consumption can supplement efforts to combat mineral deficiencies in the region. Deficiency in minerals can have a major impact on health and nutrition of a people. In the present study, both macro (Na, K, Ca, Mg, P) and trace elements (Zn, Cu, Fe, Mn) were analysed because they are of most public health importance in the region; quite often limited in diets of the resource-poor and other vulnerable persons, especially pre-school children, adolescents, HIV/AIDS infected persons, pregnant and lactating women [24].

But like other pulses, chickpea contains anti-nutritional factors such as tannins, trypsin inhibitors, oxalates and phytates, which affect nutrient bioavailability, thus imposing a restriction on its consumption. Tannins interact with proteins to form complexes, which decrease protein digestibility and protein solubility, reducing protein bioavailability [25]. They also inhibit the utilisation of nutrients through astringency and enzyme inhibition. Trypsin inhibitors are a widespread anti-nutritional substance which blocks trypsin activity thereby reducing digestibility of proteins. The major concern about the presence of phytate is its negative effect on mineral absorption. Minerals of concern in this regard include Zn, Fe, Ca, Mg, Mn and Cu [26]. Consumption of high oxalate-containing foods has been linked to recurrent nephrolithiasis in some kidney stone patients [27]. However, chickpea is considered a relatively low oxalate- containing food, with 9 mg/100g (wet weight) compared to most other legumes that contain 42-469 mg/100g (wet weight) of oxalates [27] but its oxalate bioavailability has not been extensively studied.

Removal of undesirable components is therefore essential to improve the nutritional quality of legumes and effectively utilise their full potential. Reduction in the amount of most anti-nutritional factors, either by technological and house processing or by endogenous enzymatic catalysis during seed germination has been reported [28]. Different processing treatments (germination, boiling, pressure cooking and roasting) are known to effectively reduce the content of anti-nutritional factors and improve the bioavailability of the proteins and other nutrients in chickpea [28]. As phenolic tannins are water soluble, they may be eliminated by thermal and hydrothermal processing treatments. Cooking generally inactivates heat-sensitive factors such as protein inhibitors. In many instances, the use of only one method may not completely remove a given anti-nutritional compound and a combination of two or more methods is required [29]. Seed germination also has a documented effect in the removal of anti-nutrients in legumes, since it mobilises those compounds which are thought to function as reserve nutrients, for example; phytates, oligosaccharides and, in some instances, protein anti-nutritional compounds [29]. The presence of anti-nutritional factors identified should therefore not pose a problem to humans if the seeds are properly processed.

From a nutritional point of view, chickpea contains higher contents of protein, crude fat, ash and all analysed mineral elements except Cu, than bananas. Comparing the observed mineral element content to WHO’s recommended dietary allowances [30], the chickpea cultivars analysed in this study may provide sufficient amounts of Ca, Fe, Zn, Mn and Cu in human diets and have a potential to meet human dietary requirements in an adequate manner among different age groups. In view of the overall proximate and chemical composition analysis, these five chickpea cultivars can be considered as an economic and alternative protein source that could supplement efforts to alleviate protein and trace element malnutrition in the region. The results in this study revealed that selection of the cultivars for cultivation in SWAEZ can be one of the options to improve the protein and mineral status of the vulnerable groups in the region.

CONCLUSION

In conclusion, the cropping method did not significantly affect the chickpea seed proximate content but affected all chemical element contents analysed except Ca, Cu and P. The findings of this study also demonstrate that the five analysed chickpea cultivars are a good source of protein. Mineral element analysis showed that all the chickpea cultivars were rich in trace elements, especially Zn and are therefore a potential source of micronutrients in the diets of resource-poor households in South Western Uganda Agro ecological Zone.

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Table 1: Proximate composition (Dry Matter basis) of chickpea cultivars used in the study

	Moisture	Ash	Crude Protein	Crude fat	Crude fibre
Cultivar			% DM		
ICCV 00108	11.72 ± 0.32^{a}	3.46 ± 0.25^{a}	18.00 ± 0.28^{a}	4.15 ± 0.74^{a}	10.41 ± 2.17^{b}
ICCV 00305	11.44 ± 0.30^{a}	3.51 ± 0.52^{a}	19.04 ± 0.62^{a}	4.69 ± 1.02^{a}	4.43 ± 0.04^{a}
ICCV 92318	11.70 ± 0.46^{a}	3.38 ± 0.18^{a}	17.59 ± 0.34^{a}	4.54 ± 0.53^{a}	4.83 ± 0.74^{a}
ICCV 96329	11.11 ± 0.97^{a}	4.12 ± 0.20^{a}	18.13 ± 0.90^{a}	4.37 ± 0.99^{a}	6.48 ± 3.03^{a}
ICCV 97105	12.14 ± 0.21^{a}	12.14 ± 0.21^{b}	18.52 ± 0.83^{a}	3.29 ± 0.04^{a}	11.20 ± 0.88^{b}

Values are means ± SD, n=3. Means within column with different superscripts are significantly different ($P < 0.05$).

Table 2: Effect of cropping method on proximate composition (% DM) of different cultivars of chickpea

Cultivar/cropping method		Moisture	Ash	Crude protein	Crude fat	Crude fibre
ICCV 00108	Monocrop	11.70 ± 0.20^a	3.43 ± 0.03^a	18.00 ± 0.50^a	4.20 ± 0.02^a	10.42 ± 0.07^a
	Intercrop	11.74 ± 0.05^a	3.49 ± 0.02^a	18.00 ± 0.20^a	4.10 ± 0.10^a	10.40 ± 0.05^a
ICCV 00305	Monocrop	11.38 ± 0.10^a	3.50 ± 0.11^a	19.08 ± 0.09^a	4.69 ± 0.01^a	4.43 ± 0.04^a
	Intercrop	11.50 ± 0.05^a	3.52 ± 0.03^a	19.00 ± 0.13^a	4.69 ± 0.01^a	4.43 ± 0.03^a
ICCV 92318	Monocrop	11.70 ± 0.20^a	3.35 ± 0.15^a	17.55 ± 0.16^a	4.56 ± 0.07^a	4.23 ± 0.08^a
	Intercrop	11.70 ± 0.03^a	3.41 ± 0.02^a	17.63 ± 0.17^a	4.52 ± 0.07^a	4.89 ± 0.02^a
ICCV 96329	Monocrop	11.22 ± 0.23^a	4.12 ± 0.00^a	18.10 ± 0.25^a	4.33 ± 0.01^a	6.44 ± 0.06^a
	Intercrop	11.00 ± 0.20^a	4.14 ± 0.04^a	18.16 ± 0.01^a	4.40 ± 0.20^a	6.52 ± 0.02^a
ICCV 97105	Monocrop	12.12 ± 0.16^a	12.14 ± 0.02^a	18.12 ± 0.22^a	3.33 ± 0.18^a	11.00 ± 0.35^a
	Intercrop	12.16 ± 0.04^a	12.14 ± 0.04^a	18.62 ± 0.02^a	3.25 ± 0.06^a	11.4 ± 0.05^a

Data are expressed as % of seed dry weight. Values are means ± SD, n=3. Means within column with different superscripts for each cultivar are significantly different ($P < 0.05$)

Table 3: Chemical composition (dry weight basis) of chickpea cultivars used in the study

Cultivar	Macro-elements (mg/100g)					Trace elements (mg/100g)			
	Na	K	Ca	Mg	P	Mn	Zn	Cu	Fe
ICCV 00108	269.17 ± 0.20^{a}	923.84 ± 1.00^{a}	464.10 ± 1.03^{a}	95.70 ± 0.04^{a}	399.34 ± 0.16^{a}	98.54 ± 0.35^{a}	261.62 ± 0.04^{a}	25.10 ± 0.10^{a}	6.79 ± 0.03^{a}
ICCV 00305	335.82 ± 1.40^{b}	865.67 ± 0.19^{b}	478.67 ± 1.10^{b}	85.94 ± 0.04^{b}	398.17 ± 0.23^{a}	99.19 ± 0.35^{a}	240.42 ± 0.85^{b}	15.60 ± 0.34^{b}	31.26 ± 0.22^{c}
ICCV 92318	334.00 ± 2.00^{b}	865.00 ± 2.00^{b}	480.25 ± 1.00^{b}	86.65 ± 0.50^{b}	390.00 ± 1.00^{a}	111.11 ± 0.40^{c}	262.59 ± 0.66^{a}	25.98 ± 0.08^{a}	16.38 ± 0.32^{b}
ICCV 96329	590.00 ± 2.00^{c}	1055.00 ± 1.50^{c}	480.33 ± 1.00^{b}	86.67 ± 0.08^{b}	398.67 ± 0.05^{a}	80.82 ± 0.50^{b}	266.26 ± 0.95^{a}	14.98 ± 0.04^{b}	15.58 ± 0.02^{b}
ICCV 97105	429.00 ± 1.50^{d}	920.17 ± 1.50^{a}	508.50 ± 1.00^{c}	95.34 ± 0.08^{a}	400.34 ± 0.14^{a}	111.10 ± 0.55^{c}	294.16 ± 0.18^{c}	24.00 ± 0.51^{a}	25.83 ± 0.18^{d}

Values are means ± SD, n=3. Means within column with different superscripts are significantly different ($P < 0.05$)

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Table 4: Effect of cropping method on chemical composition of chickpea cultivars

Treatment		Macro-elements (mg/100g)					Trace elements (mg/100g)			
		Na	K	Ca	Mg	P	Mn	Zn	Cu	Fe
00108	Monocrop	269.17±1.99^{a}	915.84±1.00^{a}	464.17±1.03^{a}	95.84±0.01^{a}	378.34±0.14^{a}	96.34±0.25^{a}	262.62±0.03^{a}	25.12±0.10^{a}	26.74±0.04^{a}
	Intercrop	225.12±0.12^{b}	705.44±0.56^{b}	464.18±1.05^{a}	72.22±0.06^{b}	377.54±0.15^{a}	68.68±0.35^{b}	220.00±0.22^{b}	25.22±0.20^{a}	19.00±0.02^{b}
00305	Monocrop	335.84±2.40^{a}	866.67±0.17^{a}	476.67±1.17^{a}	85.84±0.05^{a}	369.17±0.03^{a}	99.16±0.32^{a}	248.42±0.83^{a}	15.40±0.29^{a}	31.19±0.21^{a}
	Intercrop	301.12±1.25^{b}	650.66±0.21^{b}	476.89±1.22^{a}	50.00±0.00^{b}	370.10±0.07^{a}	70.16±0.30^{b}	202.24±0.12^{b}	15.50±0.36^{a}	15.22±0.11^{b}
92318	Monocrop	350.00±1.00^{a}	855.00±3.00^{a}	481.25±0.45^{a}	86.25±0.10^{a}	385.00±1.00^{a}	102.11±0.30^{a}	273.57±0.68^{a}	25.95±0.06^{a}	17.34±0.36^{a}
	Intercrop	302.00±0.86^{b}	570.00±2.00^{b}	480.31±0.50^{a}	45.66±0.24^{b}	385.10±0.95^{a}	78.16±0.22^{b}	210.24±0.32^{b}	25.44±0.08^{a}	10.45±0.34^{b}
96329	Monocrop	590.00±1.00^{a}	1060.00±2.00^{a}	483.33±0.43^{a}	86.67±0.08^{a}	366.67±0.03^{a}	84.82±0.47^{a}	266.26±0.94^{a}	12.91±0.03^{a}	15.98±0.02^{a}
	Intercrop	510.00±1.00^{b}	850.50±1.68^{b}	482.35±0.46^{a}	50.00±0.10^{b}	365.88±0.04^{a}	50.68±0.24^{b}	205.22±1.00^{b}	12.89±0.05^{a}	10.00±0.02^{b}
97105	Monocrop	430.00±2.00^{a}	934.17±0.82^{a}	507.50±0.00^{a}	93.34±0.02^{a}	418.34±0.14^{a}	112.10±0.69^{a}	292.18±0.18^{a}	22.99±0.31^{a}	25.84±0.17^{a}
	Intercrop	380.00±1.00^{b}	760.22±0.65^{b}	507.90±0.05^{a}	48.55±0.10^{b}	417.36±0.18^{a}	65.12±0.55^{b}	225.58±0.20^{b}	23.00±0.36^{a}	13.12±0.12^{b}

Data expressed as mg/100g of DM. Values are means ± SD, n=3. Means within column of the same cultivar with different superscripts are significantly different ($P < 0.05$)

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