Short Research Article

ASSESSMENT OF HANDLING SORGHUM (*Sorghum bicolo~~u~~r* L. Moench) GRAINS IN PRODUCTION AREAS

Abstract

A postharvest handling farm survey was conducted on sorghum (*Sorghum bicolor* L. Moench) grains as an alternative staple crop adapted in arid and semi-arid lands. The objective of the study was to determine postharvest handling of sorghum grains. Eighty eight farmers were sampled using snowball sampling method in six sorghum growing sub-counties (~~viz.,~~ Siaya, Bondo, Njoro, Rongai, Kibwezi and Kathonzweni). Data collected was on varieties, drying method, storage form and proportion lost due to mould was analyzed using SPSS version 20 software descriptive statistic cross tabulation. Results showed that and of the farmers preferred local and improved sorghum varieties respectively. Sorghum grains were either stored in shelled form or on panicles. Mould occurrence in the field and storage in the sub-counties as hazard handling of the grains. This study further established that farmers maintain a diversity of sorghum to reduce on the proportion lost either as storage duration of grains and biotic stress resistance. The results of the study can be used to explain erratic food insecurity in these sub-counties with potential of sorghum production.

Key words: Survey, sorghum, mould, occurrence, panicle, sample ~~Post harvest handling, survey~~

Introduction

Sorghum is a cereal crop mainly adapted in the arid and semi-arid areas utilized as human food. It has a potential of providing food security in these regions as many cereal crops fail to or produce little yields [1]. The crop is characterized by extensive root system and waxy layer on leaves that reduces water loss [19]. Sorghum production areas are characterized as semi-arid low lands, moist humid and cold highlands where the study was carried out [1]. Sorghum is closely related to Maize (*Zea mays* L.) that is preferred but it mostly fails to produce or produces little yield in the marginal areas hence sorghum is an alternative staple crop [26]. Sorghum is normally used as human food, animal feed as well as industrial raw material [13]. As food in the marginal

areas the grains are milled into flour for domestic use ~~that is used in making thick porridge~~ [13]. Sorghum production is mainly by small scale farmers who are regarded as resource poor [17]. The demand for sorghum grains is high by brewing and animal feed industries but production by farmers is on averages at 0.85 t ha^{-1} below the demand [7]. This has been attributed to infestation by the birds, *Quelea quelea*, insect pests, diseases and poor post harvest handling of grains [1]. Post harvest handling of sorghum grains determines the quality and quantity for human and livestock consumption [15]. This study aimed at assessing post harvest management of sorghum grains in the sub-counties of Siaya, Bondo, Njoro, Rongai, Kibwezi and Kathonzweni with huge production potential.

Materials and Methods

Sampling procedure

A structured questionnaire was developed and cleaned for any anomalies for use in the collection of data for the assessment of post harvest management of sorghum grains. The questionnaire was pre-tested with 50 farmers at Rongai sub-county. A standard questionnaire was used in data collection in the sub-counties of study. Snowball sampling method was used in the six sub-counties of study (Siaya, 0° 26’ to 0° 18’N,33° 58’E, 34° 33’W), Bondo (0.0998° S, 34.2744°E), (Njoro, 0°19'60" S, 35°55'60" E), (Rongai, 35°51’ 49E,- 0° 10' 23 S), Kibwezi (-2 25' 00"E, 37 58' 00") and Kathonzweni (1°54'0" S, 37°43'0" E) from 15th to 30th September 2015. Kibwezi is classified as lower midland with some regions in transitional zone. Kathonzweni, Bondo and Siaya are classified as lower midland [10]. Rongai is lower highland; Njoro is upper highland [10]. Each study sub - county was considered a homogeneous sampling block area. During sampling administrative divisions, location, sub-location and villages within each sub-county were appropriately represented. A total of 88 sorghum growing farmers were randomly selected and interviewed using the questionnaire. Additional post harvest handling observations of sorghum grains were made. Data collected was analysed using SPSS computer package version 20 ~~18~~ software. Descriptive statistics cross-tabulation was used to analyse the data in percentage form of each representative sub-county.

Results

Gender and age involved in post harvest handling of sorghum grains

The survey results showed that majority (60-78%) of the sorghum farmers in Bondo, Kathonzweni and Rongai sub - counties were females. The converse was true for Siaya, Kibwezi and Njoro sub-counties where majority (52-68%) of the sorghum farmers were males (Fig.1). Many (15-26%) of the respondents farmers were less than thirty years in Bondo and Kibwezi sub - county. Majority (36-50%) of the respondents with 31-45 years were in Kathonzweni and Njoro while only (6-21%) were in Bondo and Rongai sub-counties. The respondent farmers with 46-60 years were (50-58%) in Siaya and Rongai sub-county and only (20-33%) in Kathonzweni and Bondo sub-counties. More than sixty one years of age of the farmers were many (19-33%) in Kibwezi and Bondo and only (14-18%) in Rongai and Njoro sub-counties (Fig. 2).

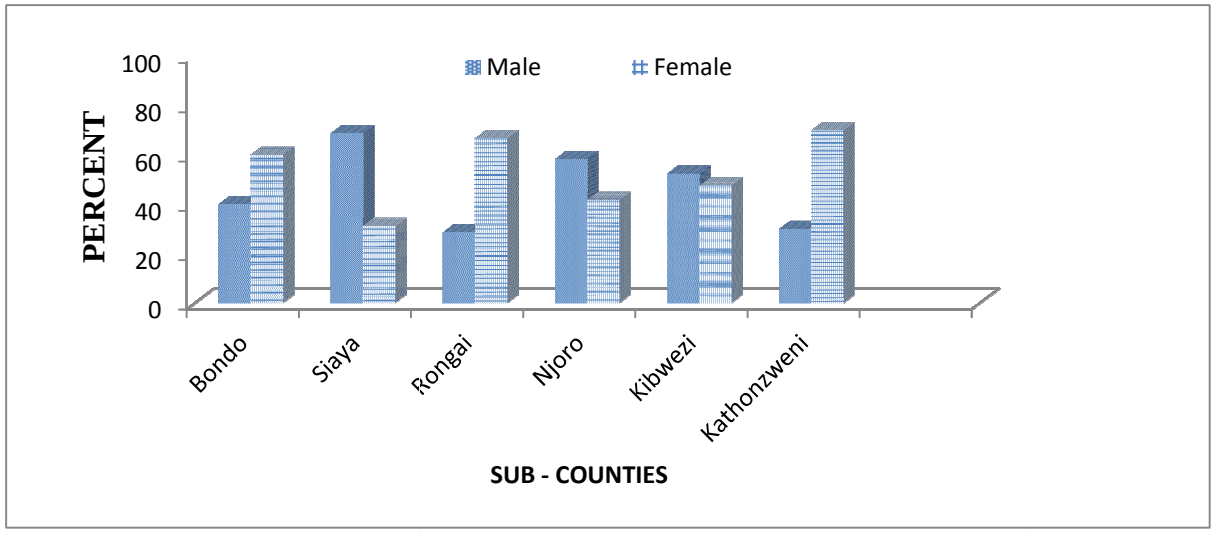

Fig.1 Distribution of respondent farmers by gender in six sub-counties

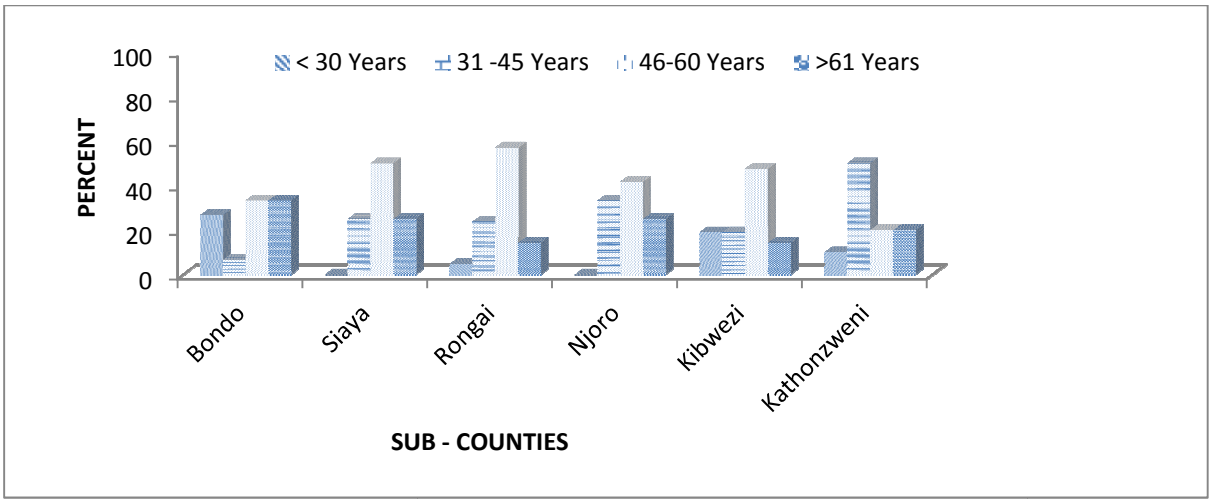

Fig.2.Distribution of respondent farmers by age in six sub - counties

Sorghum varieties grown, traits of preference and factors influencing harvesting

The results showed that the proportion of farmers preferred growing landrace in Njoro, Rongai, Bondo and Siaya. In Kibwezi and Kathonzweni preference was given to the sorghum hybrids than landraces (Table 1). The traits preferred in sorghum landraces were good storability and low mould occurrence. The hybrid sorghum varieties were popular among farmers like Kibwezi sub-county due to high yielding and early maturity. Harvesting of the crop was mainly influenced it had reached physiological maturity in the study sub-counties (Table 1).

Table 1: **Traits preference and factors influencing sorghum harvesting** (percentages)

	Bondo	Siaya	Kibwezi	Kathonzweni	Rongai	Njoro
Variety						
Landrace	60	50	20	50	70	75
Improved	40	50	80	50	30	25
Variety preference						
Y	19.7	10.3	35.0	40.0	70.0	12.0
I	80.3	73.0	50.0	40.0	20.0	85.0
S	0.0	16.7	15.0	20.0	10.0	3.0
Why harvest						
PM	85.7	91.5	95.6	98.1	87.7	89.8
BD	14.3	8.5	4.4	1.9	13.3	10.2

In the table: Y - yield, I - income, S - Storability, PM – Physiological maturity, BD - Bird damage

Post-harvest handling of sorghum grains

Majority of the respondent farmers handled their sorghum grains differently after harvesting to reduce on loss quality and quantity. This was mainly sun drying on various forms that was

available to them but not limited to polythene sheet, on bare ground and house roof tops. Sorghum grains were either stored in gunny or sisal bag either in panicle or shelled form, in a traditional or improved granary and living room. Sorghum grains storage duration varied among the respondent farmers as from 1 – 6 months in the study sub-counties (Table 2).

Table2:Post-harvest handling of sorghum grain(percentages)

	Bondo	Siaya	Kibwezi	Kathonzweni	Rongai	Njoro
Sun drying form						
BG	10.2	14.2	35.3	42.4	10.0	1.5
PE	85.5	79.1	60.7	50.4	87.5	94.3
HRT	4.3	5.7	14.0	7.2	2.5	4.2
Grains stored form						
Shelled	90.2	79.1	93.9	99.3	70.7	83.1
Panicle	9.8	21.9	6.1	0.7	29.3	16.9
Granary structure						
Traditional	45.0	40.7	25.0	15.8	17.0	1.7
Improved	20.5	25.3	37.9	69.8	75.0	66.3
Living room	34.5	34.0	37.1	15.0	8.0	32.0
Storage form						
Sisal bag	35.1	3.6	21.2	23.5	11.3	8.6
Gunny bag	64.9	96.4	77.8	76.5	88.7	91.4
Duration in store						
1 - 3	50.3	15.4	23.5	40.0	56.0	59.4
4 - 6	47.7	84.6	76.5	60.0	44.0	40.6

In the table: BG - bare ground, PE - polyethene, HRT – house roof top

Mould occurrence on sorghum grains and losses associated

Mould occurrence on sorghum grains was either in the field or in storage among the respondent farmers in the study sub counties. Mould infestation on grains in storage was highly reported highest in Njoro. This led to a large proportion of sorghum grains being discarded due to moulding. Losses attributed to occurrence of mould in sorghum grains either in the field and storage was relatively of large proportion in Kibwezi and Siaya sub-counties (Table 3).

Table 3: Mould occurrence on sorghum grains and losses associated (percentages)

	Bondo	Siaya	Kibwezi	Kathonzweni	Rongai	Njoro
Mould occurrence						
Field	67.0	71.0	50.7	87.0	91.4	79.7
Storage	23.0	29.0	49.3	13.0	8.6	20.3
Mould due losses						
Very little	70.5	67.0	88.0	82.0	94.0	96.0
Large	29.5	33.0	12.0	12.0	6.0	4.0

Impact of mould occurrence on sorghum grains and strategies for minimizing

The farmers were food insecure as a result of infestation of sorghum grains with mould. The households across the study sub-counties discarded their infested sorghum grain with mould this led to food insecurity as it was the main staple food in the region. The households that consumed moulded grains except in Njoro and Rongai study sub-counties. The strategies used by the respondent farmers in mitigation strategies were storage hygiene in the occurrence of moulded sorghum grains study sub-counties (Table 4).

Table 4: Impact of mould occurrence on sorghum grain and strategies (percentages)

	Bondo	Siaya	Kibwezi	Kathonzweni	Rongai	Njoro
Impact of grain mould						
Utilize moulded grains	52.9	60.5	70.7	59.0	10.0	10.1
Food insecure	47.1	39.5	29.3	41.0	90.0	89.9
Household action						
Discard grains	15.1	10.3	0.0	5.0	3.0	20.2
Storage hygiene	84.9	90.7	100.0	95.0	97.0	79.8

Discussion

An assessment of the post harvest handling of sorghum grains in the sub-counties that have huge potential of production. The losses that occur to the grains start from the field either as birds and mould infestation. This is carried over to storage as either mould due to poor drying, storage form and storage duration of the grains. The study found out that most of the post harvest handling work of the grains was done by females which concurs with [10] study in Eastern region of Kenya that women are fully involved in planting, bird scaring, harvesting and post harvest processing of sorghum [11]. Their roles are highly influenced by expectations based on age as women tend to concentrate their agricultural activities around the homestead, food production, post harvest activities [6]. This is in agreement with the findings of [2]. Victoria ~~Beard~~ (2005) who noted that there is a marked distinction in the role of gender in traditional African agriculture and activities ascribed to men and women on the basis of perceived differences in rural farming households vary widely across cultures.

The farmers in the sub-counties preferred sorghum landraces compared to improved varieties. This is in agreement with [14] that showed most farmers in eastern part of Kenya grow sorghum landraces which is used for food among other uses. Traits preferred by respondent farmers who

grow landraces were good storability, not attacked by birds. This is in agreement with a study conducted in India, by [20] that showed farmers planted sorghum varieties that were good in quality of grain, resistance to biotic and a biotic stresses [24]. Abiotic and biotic stress limits plant growth and crop productivity. Changes in precipitation patterns due to climate change and meteo- climatic variability have become a critical issue and a limiting factor for the crops under rain-fed systems [24]. For instance the improved varieties of sorghum, the structural carbohydrates (cellulose, hemicelluloses and lignin) and biomass yields are significantly affected by drought stress [29]. Climate change is associated with an increase in the frequency of heat stress, droughts, and floods that negatively affect crop yields and biomass production and the ability of the climate smart sorghum to adapt and yield under such harsh environment [30]. This is also concurred with a study conducted in Mali showing farmers were interested in variety adaptation to general environmental conditions, yield and resistance to different biotic stresses [25]. Improved high - yielding varieties have been ignored by majority of farmers for preference of landraces (*Nyakabala, Andiwo, Rakwar, Ofunjo* and *Nyakidi*). This is attributed to the landraces have a hard endosperm and are bitter in taste hence undergo less bird damage as compared to the improved varieties which have a soft endosperm [21]. This is agreement with [16], that quality of sorghum grain variety used as food determines its acceptability by the farmers while adaptation to biotic stresses determines the survival in the field and in storage [4]. The hybrid varieties were unpopular among many farmer except in Kibwezi and Kathonzweni due to the attack by birds. This is in agreement with [5], that improved sorghum varieties have low tannin content are highly prone to birds' damage hence reducing the yield and not popular among farmers. The survey findings show that improved varieties have an advantage over the local varieties of early maturity and high yielding [23]. These advantages are however weighed down by the high susceptibility of the improved varieties to bird damage and attack by grain mould [9]. The improved varieties have not been popular in production by many farmers due to lack of awareness of the varieties to the farmers so as to increase their adoption by farmers [18].

Post harvests handling of sorghum grains among majority of farmers are like sun drying, threshing and storage. Farmers threshed grains from panicles by beating with sticks or rubbing the panicle on a hard surface like a rough stone or storing it on panicles. This contributes to high mechanical damage due to the breaking of seeds into small pieces hence reduces the quality. This concurs with, [3] that showed when seeds within a seed lot are broken into pieces; the

embryos are damaged hence reducing the germination capacity of the seeds. Drying of sorghum panicles or threshed grains in direct sunlight by farmers lead to reduced seed quality due to high temperatures; they lose vigour and viability [8]. Sorghum grains were stored in traditional/improved granary or in living room. The ecosystem within stored grain structures is limited in microbial species because of human efforts to maintain grain quality. Mould fungi infection on sorghum grains that was observed in the field and storage by the farmers. Few fungal spores are found on grain this lead to loss in quality and quantity in cereal grains. This concurs with [27], who showed that, at harvest, grain contains populations of field microbes. As the grains are placed into a storage facility, a succession of microbial species begins to grow. Without intervention, microbial respiration will lead to an increase in temperature and moisture, providing optimum growth conditions for fungal species. This is in agreement with the finding of [27] who noted that fungi species depend on type of grain, moisture and temperature will influence the specific fungi that are associated with grain [22]. The amount of water available in an environment is measured in moisture content fluctuates in dry environment in equilibrium with the relative humidity of the air surrounding grain mass leading to mould fungi infection [28]. This finding was similar to the report of [12] that several toxins producing spoilage fungi dominates on cereals in tropics and temperate zones

Conclusions

Farmers preferred the local varieties as it would be stored for a period of time. Sorghum landraces are less prone to mould infestation than the improved varieties. The improved varieties are often attacked by birds. ~~preferred by farmers as the produce was not as prone to mould attack as the improved varieties as well as attack by birds. The hybrid varieties were popular among farmers as they produced high yield.~~

References

1. Barnett, H. L. and Hunter, B. B. (2003).Illustrated Genera of Imperfect Fungi.University Missouri Press, Columbia, Pp. 68, 94, 106, 130 and 132.
2. Victoria, A. B. (2005). Individual determinants of participation in community development in Indonesia. Environment and Planning C: Government and Policy 23: 21 – 39.

3. Blackwell, M. (2011).The fungi 1, 2, 3… 5.1 million species? *American Journal of Botany* 98:426 - 438.
4. Cromwell, E. and Zambezi, C. (1993).The Performance of the Seed Sector in Malawi, an Analysis of the Influence of the Organization Structure. Overseas Development Institute, London, UK,
5. Cormwell, E., Friis - Hanses, E. and Turner, M. (1992). The seed sector in developing countries: a framework for performance analysis. Working Paper Pp.65.
6. Fakoya, E. O., Adereti, F. O. and Apantaku, S.O. (2006).Gender Involvement in Arable Crop Cultivation and its Contributions to Household Food Security in Ogun state *Research Journal of Social Sciences* 1 (1):1 - 4.
7. Gerda, M.B. and Christopher, D.V. (2007). Can GM sorghum impact Africa *Trends in Biotechnology* 26:64 - 69.
8. Huang, Y. (2004). Evaluation of genetic diversity in sorghum germplasm using molecular markers. International Plant and Animal Genome XII Conference, San Diego Pp. 265.
9. Haugeraud, A. and Collinson, M. P. (1990). Plants, Genes and People: Improving the Relevance of Plant Breeding in Africa *Experimental Agriculture* 26:341 - 362.
10. Jaetzold, R., Schmidt, H., Hornetz, B. and Shisanya, C. (2006).Farm Management Handbook of Kenya, Vol. II/C1.Ministry of Agriculture, Kenya and German Agency Technical team.
11. Kenya Food Security Steering Group (KFSSG) (2008).Machakos District Long Rains Assessment Report: 28th July - 1st August.
12. Lacey, J., Ramakrishna, N., Hamey, A., Magan N., and Marfleet, I. C. (1991).Grain fungi. In: Arora, D. K., Mukerji, K. G., and Marth, E. H., (Eds.) *Handbook of applied mycology, foods and feeds.* Marcel derkker New York. U.S.A., Pp 121 - 177.
13. Mamoudou, H. D., Hurry, G., Alfred, S., Alphons, G. J. and Van, B. (2006). Sorghum grain as human food in Africa: relevance of content of starch and amylase activities *African. Journal Biotechnology* 5:384 - 395.
14. Ministry of Agriculture (MoA) (2010). The Annual Report, Crop Development Division, Kenya.
15. Muasya, R. M., Lommen, W. J. M., Muui, C. W. and Struik, P. C. (2008). How weather during development of common bean (*Phaseolus vulgaris* L.) affects the crop's

Maximum attainable seed quality. NJAS - Wageningen*Journal of Life Science* 56 (1):85 - 100.

16. Muui, C. W., Muasya, R. M. and Kirubi, D. T. (2013).Baseline survey on factors affecting sorghum production and use in eastern Kenya.*African Journal of Food, Agriculture, Nutrition and Development* 13(1):7339 - 7342.
17. Muliokela, L. A, Mathenge, P. W. and Muasya, R. (2011). A survey of on-farm seed production practices of sorghum (*Sorghum bicolor*L. Moench) in Bomet district of Kenya *African Journal of Food, Agricultural Research* 11:5.
18. Nyongesa, T. E. and Johnson, J. (1990).The Acceptability of New Seed Varieties, report of a Survey to Determine Farmers' Response to New Varieties, Embu, Kenya.
19. Paterson, A. H. (2008). Genomics of sorghum (A review).*International Journal of Plant Genomics* Volume 2008, Article ID 362451; doi : 101155/2008/362451.
20. Rana, B.S., Kaul, S.L., Chari, A., Prabhakar, K. S., Belum, R., Witcombe, J. R. and Virk, D. S. (2000)."Participatory varietal selection in rabi sorghum in India". International conference on "Participatory plant breeding and plant genetic research" Pokhara, Nepal
21. Salasya, B., Odendo, M. and Odenya, J. (1996). Evaluation of Sorghum Technology Adaptation Levels in Homa Bay District in: Fungoh PO and GCO Mbadi (Eds). Focus on Agricultural Research for Sustainable Development in a Changing Economic Environment. Homa Bay, Kenya.
22. Sinha, R. N. (1992). The fungal community in the stored grain ecosystem. In: The Fungal Community (eds., G. C. Carroll and D. T. Wicklow) Marcel Dekker. Pp. 797 - 815.
23. Singh, R. (1990). Farmers' maize seed systems in western Oromia Ethiopia.The seed enterprise development project. The Ethiopian Agricultural Research Organisation, Pp. 32.
24. Songa, W., Ronno, W. K. and Danial, D. L. (1995).Production Constraints of Beans in the Semi-arid Eastern Kenya with special reference to Charcoal rot. Proceedings of a Regional Workshop for Eastern, Central and Southern Africa, held at Njoro, Kenya, Oct. 2-6, 1994. *Wageningen Agricultural University, Wageningen* 251 - 255.
25. Sthapit, B. R., Joshi, K. D. and Witcombe, J. R. (1999).Farmer Participatory Crop Improvement. III. Participatory Plant Breeding: A Case Study for Rice in Nepal. Experimental Agriculture.32:479 - 496. Singh, R (1990).Farmers' maize seed systems in

western Oromia Ethiopia.The seed enterprise development project. The Ethiopian Agricultural Research Organization Pp. 32.

26. Swigonova, Z., Lai, J., Ramakrishna, W. and Llaca, V. (2004).Close split of sorghum and maize genome progenitors *Genome Research* 14:1916 – 1923.
27. Wicklow, D. T. (1995). The mycology of stored grain: an ecological perspective. In: Stored-Grain Ecosystems. (eds., D. S. Jayas, N. D. G. White, W. E. Muir) Marcel Dekker Pp. 197 - 249.
28. Yanagita, T. (1990). Water availability In: Natural Microbial Communities, Ecological and Physiological Features. Springer - Verlag Pp. 219 - 235.
29. Zegada-Lizarazu , W. , and A. Monti . (2013). Photosynthetic response of sweet sorghum to drought and re- watering at different growth stages. Physiology of Plant. 149: 56 – 66.
30. Kim , K.-H. , E. Kabir , and S. Ara Jahan . (2014) . A review of the consequences of global climate change on human health . J. Environ. Sci. Health Part C 32: 299 – 318 .