Local Community's Knowledge on Onion Production, Pests and Pests Management in Kilosa and Kilolo Districts, Tanzania

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Abstract

To assess local community's knowledge on onion production, pests and pests management a baseline survey was carried out in Kilosa and Kilolo Districts. The results indicated that more than 36% of onion producers were middle aged (34-49 years) and were literate at least with secondary education (80%). Onion production was the major source of livelihood to more than 80% of hundred onion farmers (40 females, 60 males) interviewed. Up to three onion crops per year from different fields were realized due to availability of means for irrigation mainly by flooding and the main production season was from March-July under monoculture or in the intercropping. Eighty four per cent of onion farmers own land and production was on small scale holders. Fifty per cent of small scale farmers produced onion on land size of 0.25-2.0 acres.Onion varieties grown were Red Bombay, Red Creole and Khaki with preference to Red Bombay (72%) for its high yield, marketability and bulb size while Khaki (21%) was chosen for its storability. Onion seed sources were from other farmers (40%) and were expensive, which means the cost for seeds were beyond a prospective farmer's affordability. The most prevalent pests reported by interviewees were thrips (Thrips tabaci) (73%), weeds led by Mexican poppy (Argemone mexicana) (55%) and fungal diseases led by purple blotch (55%).Onion production was found to be the major source of livelihood to more than 80% of farmer respondents. The challenges observed were such as source of improved seeds, means to combat pests and lack of higher yielding varieties which can resist insect pests and diseases. The IPM package on management of the most prevalent pestsis required to reduce onion yield losses.

Keywords: Onions, baseline survey, onion varieties,

Introduction

Onion (*Allium cepa* L.) is an important vegetable crop in most areas of the world (Cramer, 2000), particularly developing countries. According to FAO (2008), an estimated global production is almost 28 million metric tons per annum. A global review of fifteen major vegetables listed by FAO shows that onion ranks second after tomatoes in area under cultivation (Pathak, 2000). According to FAOSTAT (2010), there are 7 million acres under onion cultivation with yield of 37 million tonnes each year. Global average onion yield in 2004 was estimated at 18 t/ha with Africa producing 15.21 t/ha (FAOSTAT, 2010). In many growing regions, it is a major source of income for rural families who sell their produce in local, regional and international markets. The world major onion production per unit area is the Korea Republic (67.25 t/ha) followed by USA (53.91 t/ha), Spain (52.06 t/ha) and Japan (47.55 t/ha) (FAO, 2008).Tropical countries, having about 45% of the world's arable land grow about 35% of the world's onions (Kariuki and Kimani,1994).

Onions are grown in a wide range of climatic conditions, from relatively hot and dry areas to fairly cool and humid zones (Kariuki and Kimani,1994). In Tanzania, onion is the most important spice vegetable. The country ranked tenth amongst onion producing countries in Africa with production of about 56,000 tonnes of onion annually (FAO, 2000). The crop is produced almost all over the country from the Southern Highlands through the Central Plateau to the Northern Highlands. Production is mainly

for local consumption and domestic market although exports for foreign markets are growing exponentially (Anon, 1991). Though Tanzania produces a significant quantity of onions, it is not sufficient enough to meet the demands for both domestic requirement and exports. Low yields are common experience in onion production in Tanzania. In Tanzania onion yield in 2001 was 11 t/ha (Muendo and Tschirley, 2004) indicating an increasing trend. Tanzanian farmers produce onions in the midst of various pests and with few varieties which their reaction to pests of economic importance is not understood. In this regard, a baseline survey was carried out to establish the information known to farmers on onion production, pests and pests management. The information obtained from this study is useful to initiate onion integrated pests management package in Tanzania.

Materials and Methods

The baseline survey on onion production and pests' management was conducted in two districts; Kilosa and Kilolo, located in Morogoro and Iringa regions respectively during 2012-2013 cropping seasons. The villages involved were Chabi and Malolo B from Kilosa district and Msosa from Kilolo district. A structured questionnaire was designed, pre-tested and finally administered to farmers who were identified to be onion growers. The respondents' were selected randomly in each village after consultation with village and ward executives and gender representation was taken into

Table 1: Socio-economic characteristics of onion growers in Kilosa and Kilolo Districts (N=100)

Variable		Category	N	%
Respondents per district		Kilosa	23F[1] + 27M[2]	50
		Kilolo	17F + 33M	50
Household composition		Household heads	10F + 54M	64
		Spouse	27F + 4M	31
		Daughters/Sons	3F + 2M	5
Age (Years)		Youth (18-33)	13F + 9M	22
		Middle (34-49)	22F + 36M	58
		Old (50-69)	5F + 15M	20
Level of education		Primary	4F + 8M	12
		Secondary	36F + 50M	86
		Tertiary	2M	2
[3]Income from sales of crops per season (Tanzanian Shilling)	Onions	< 1.0	1	1
		Between 1.0 to 5.0	11	11
		Between 5.0 to 10.0	23	23
		>10.0	45	45
	Paddy	Between 1.0 to 5.0	1	1
		Between 5.0 to 10.0	5	5
		>10.0	4	4
	Maize	< 1.0	3	3
		Between 1.0 to 5.0	4	4
		>10.0	1	1
	Beans	Between 1.0 to 5.0	1	1

[1]Female;
[2]Male;
[3]All figures to be multiplied by 100,000 and 1 USD = 1540 Tanzanian Shilling.

consideration where by both males and females of youth stage to adult had an equal chance of being selected to participate in the study. The number of farmers from each village wasproportional to the population of smallholder farmers growing onions in each village. The selection was based on proportionality of the total number of onion growers in each surveyed village. A total of 100 small holder onion farmers (60 males and 40 females) participated in the interview in each district to establish background information on onion growers, onion production, storage and marketing, pests prevalence, current pest control measures (if any), farm characteristics and operational constraints. Data were analysed by SPSS computer package.

Results

In thebaseline survey a total of 60 (60.0%) males and 40 (40.0%) females onion farmers were interviewed (Table 1). Out of 100 onion farmer respondents, 10 (10.0%) females were heads of the households, while 54 (54.0%) males were household heads. The female spouses were 27 (27%) and male spouses were 4 (4.0%). Others were daughters 3 (3.0%) and sons 2 (2.0%). Age of the respondents ranged between 18 years and 69 years. Most of the respondents (female 22 [22.0%], males 36 [36.0%]) were middle aged between 34 – 49 years (Table 1). Eighty six per cent of male and female respondents had secondary education, 12% had primary education and no female had attained tertiary education.

Most of the onion farmer respondents (80.0%) indicated that onion production was their major source of family income (Table 1 and Fig. 1). Majority (68.7%) of the respondents earned more than TSh. 500,000/=, however only 45.5% were getting more than TSh. one million from sales of onions annually. Other crops that were produced included paddy, maize, beans. In addition, rearing of livestock like goats, cattle and chicken were undertaken. The results from this study show that onion production is the major source of income for most of the farmers in the study area gaining between TSh 100,000 - 1,000,000 per season to 80% of small scale farmers (Table 1).

Due to possibility to irrigate onion crop, production in the study area was done in three seasons or cycles per annum. The three onion cropping or cycles were December-April for cycle one, March-July for cycle two and June-October

Table 2: Onion production seasons, cropping systems and land ownership

Variable	Category	n	%
System of onion cropping	Monoculture	65	65
	Mixed cropping	11	11
	Relay cropping	24	24
Number of productions per year	One season only	52	52
	Two seasons	39	39
	Three seasons	9	9
Irrigation method	Basin	18	18
	Flood	80	80
	Furrow	1	1
Source of water	River Msosa	21	21
	River Ruaha	27	27
	River Sisima	25	25
	River Chabi	5	5
Land ownership	0.25 acres to 2.0 acres	50	50
	<2.0 acres to 4.0 acres	21	21
	4.0 acres to 29.0 acres	13	13
	Renting	16	16

for cycle three. Majority of farmers (52.0%) were producing onions for one season (cycle 1) per year while some of them (9.0%) were producing onions for all three seasons (cycles 1, 2 and 3). Thirty nine per cent of onion farmers, majority of them being from Msosa village, were producing onions for two seasons (cycles 1 and 2) per year. However, the main production season was from March-July. Seed sowing in nursery was done in December-January, followed by transplanting in the field from February to April. Thus harvesting was mainly from July to August. The same plots were used for all other crops and therefore, some onion farmers practiced mono-cropping while others carried out mixed cropping (11.0%) and relay cropping (24.0%). Many onion farmers (65.0%) in the study area grow onions under a monoculture cropping system (Table 2).

However, most plots planted with onion were observed to be intercropped with maize on the edges of beds as is indicated in Plate 1.

Plate1: Onion crop intercropped with maize in Msosa village

All seasons for onion production required water supplementation by irrigation. However, the onion grown in the third cycle (June – September) requires more frequent irrigation because of drought spell. Water for irrigation was obtained from four rivers namely Msosa and Ruaha (for Msosa village) Sisima and Chabi (for Malolo B and Chabi villages respectively). The majority (80.8%) of onion farmers were using flood irrigation. Others used basin irrigation and furrow irrigation as indicated on Table 2. Water charges per annum ranged between TSh. 1,500/= and 450,000/= while labour charges for irrigation ranged between TSh. 3,000/= and TSh. 3.6 million depending on acreage. Distance from water source to field varied significantly, while some onion fields were located about 500 m from the water source; others were located as far as 2 km away.

The land ownership characteristics indicated that majority of farmers 84 (84.0%) cultivated onions from their own land. Farmers in all villages owned land ranging from 0.25 to 29 acres(0.1 – 10.12 ha). Half of the onion farmer respondents (50.0%) owned from a quarter to two acres. The cost for renting an acre of land for onion production ranged from TSh. 20, 000/= to 200,000/= with a mean of TSh. 60,000/= per acre. The land rent cost was relatively higher particularly during the dry season for fields closer to water source for irrigation.

Three different onion varieties were grown in the surveyed area namely: Red Creole, Khaki and Red Bombay, also known as Lumuma Red when seeds were bought from Lumuma where onion farmers locally produce seeds for their own use and sale. The majority of farmers were growing Red Bombay (79.0%), followed by Khaki (14.0%) and Red Creole (7.0%) as shown in Fig.1.

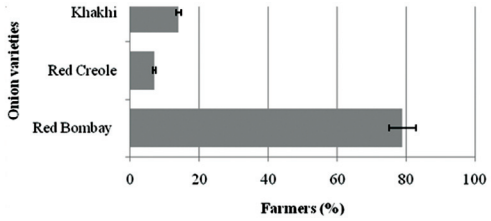

Figure 1: Onion varieties produced in Kilosa and Kilolo districts

Reasons for variety preference are shown in Fig. 2. Red Bombay (72%) was more preferred for its marketability, high yield, large bulb size and early maturity. Khaki (21%) variety was preferred for its good storability characteristic when compared to other 2 varieties.

Most onion farmers (40.8%) buy seeds from other farmers, 18.3% from Lumuma (another ward in Kilosa District which also produce onions), 16.3% produced their own seeds and 13.3% buy onion seeds from shops and other agro-dealers while 11.2% were getting seeds

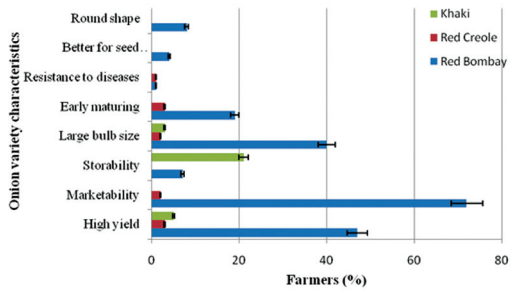

Figure 2:Characteristics which led to onion varietal preference in Kilosa and Kilolo districts

from Arusha (Mang'ola), another region located in the northern part of Tanzania (Fig. 3).

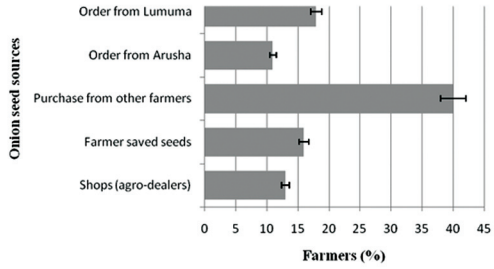

Figure 3: Source of onion seeds used by farmers in Kilosa and Kilolo districts

Cost of seeds in onion production varied a lot. Farmer own produced seeds were sold between TSh. 5,000/= and 20,000/= per one litre-tin (approximately one kilogram) depending on the source. Seeds from other sources like Arusha and other agro-dealers were relatively expensive as the prices were as high as to TSh. 200,000/= per kg.

Insect pest known to be important in the study area included; onion thrips (*Thrips tabaci*), elegant grasshopper and onion grub. Onion thrips was mentioned by most (89.0%) onion farmer respondents to be an important pest in the study area, while Onion grub (*Phyllophaga* spp.) was mentioned to be new in the area specifically in Chabi village. Normally the grubs live in the soil and are not visible unless you unearth the field. The damage caused by grubs is cutting the onion beneath the soil surface thus causing wilting. Farmers from the study area did not have any control measures on onion grubs except 'hand picking and destruct'. When insects were ranked in order of their importance, onion thrips was considered the most destructive pest (72.7%), followed by onion grubs (16.4%) and grasshopper (6.3%) (Fig. 4). Fifty five per cent of the onion farmer respondents indicated that fungal diseases and especially onion purple blotch was the most destructive especially on crops planted during rainy season. Respondents (73%) reported to be using chemical control methods in combating onion pests and were purchased from local agro-dealer shops. The most used pesticides were Selecron, Karate (insecticides), Dithane, Ridomil, Bravo and Blue copper (fungicides) as well as Stomp, Galgan, Volmethalin and Dizuron (herbicides). About 74% of farmers used inorganic fertilizers. Only 1.1% were borrowing inorganic fertilizers and pesticides from other farmers, while 25.5% were getting fertilizers only from the Government at subsidized price. The most common fertilizers used in the study area were Urea, Calcium Ammonium Nitrate (CAN) and Di–Ammonium Phosphate (DAP) and foliar fertilizers of various brand names. Only four farmers indicated to use farmyard manure from time to time when it was available.

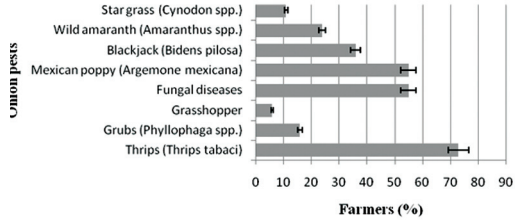

Figure 4: The most frequent troublesome pests reported to occur in the onion fields at Kilosa and Kilolo districts

The most common troublesome weed species reported by 55% of respondents was Mexican poppy (*Argemone mexicana*) (Fig. 4 and Plate 2) locally known as *kihondo*, followed by black jack (*Bidens pilosa*). Other weeds were wild amaranth and annual and perennial grasses.

In Msossa village weed control in onion production was done by using herbicides followed by hand pulling. In Malolo B and Chabi villages most of farmers (79%) practiced mechanical weeding (hand pulling only). The spacing (15cm

Plate 2: Severe weed (*Argemone mexicana*) infestation in onion crop – onion crop at bolting stage

x 20 cm) used in onion production does not allow the use of the hand hoe in weeding, and therefore use of herbicide followed by hand pulling has become a more popular weed control practice.

Discussion

Fifty eight per cent of the onion farmers were middle aged between 34 and 49. This age group is considered to be energetic and can perform most of the agricultural activities. Ozor and Cynthia (2010) found that the middle age group farmers were active in adoption of effective measures concerning farming. More than 80.0% of onion farmers had secondary education. Education will make onion farmer more exposed to new information and technologies; and more able to deal with technical recommendations that require a certain level of literacy. This indicates that most of onion farmers were literate and can take effective IPM measures towards protection of their onion crops. Education has been shown to be a factor in the adoption of farm practices that aim at higher yield (Obinne, 1991; Agwu and Anyanwu, 1996). Also Agwu *et al.* (2008) reported that educated farmers were advantaged for adoption of farm innovations in their study of disseminating improved agricultural technologies through radio farmer program.

Water charge per annum was high. It should be noted that the figures are a bit high due to the fact that in some cases; irrigation water charges were not paid in cash but in exchange with an agreed number of onion bags and therefore, the indicated values were obtained by calculation using prevailing onion prices. Although this was regarded desirable by a number of farmers, it does not seem to be a fair play between the two parties, the fact which calls for a need to train farmers on the same.

Intercropping onion with other crops especially maize was found a common practice in the study. The studies in Kenya had shown onion purple blotch severity and area under disease progress curve reduction of up to 18% in the intercropping of onions with other plants such as spider plants, carrot and French beans (Narla *et al.,* 2011).

'Lumuma' seed source was noted with interest because onion farmers mentioned to get 'quality seeds' from this place. Apparently some farmers in Lumuma village were known to produce quality declared seeds (QDS) of onion. QDS is a seed class produced under community seed multiplication and is certified only at 10% by Tanzania Official Seed Certification Institute (TOSCI), a seed certification body in the country. However, onion seed producers from the study area were not producing QDS because of lack of capacity which involves training, farmers' registration by TOSCI as QDS producers and initial quality basic seed. Quality declared seed producer capacity building, registration and information on how to obtain basic seed as a source for QDS production is according to The Seed Act No. 18 of 2003 (MAFC, 2003).

In this study, thrips was the highest ranking pest followed by fungal diseases specifically purple blotch, Mexican poppy weeds (*Argemone mexicana* L.), other weeds, grubs and grasshoppers. The thrips infestation was also reported by the survey in seven districts in Kenya where onions are grown. Farmers from these districts ranked thrips as the most important insect pests of onions (Waiganjo, 2012). Onion thrips (*Thrips tabaci* Lindeman) (*Thysanoptera: Thripidae*) is reported to be the insect pest of economic importance since its description in 1888 by a Russian entomologist Karl Eduard Lindeman (Diaz-Montano *et al.,* 2011). Thrips infestation in onion can cause yield loss of up to 60% (Waiganjo *et al.,* 2008). Young plants are more susceptible. Apart from damage on leaves through feeding, thrips are known to transmit *Iris Yellow Spot Virus*, IYSV which infects onion and is only transmitted by *T. tabaci*. Iris yellow spot disease has caused serious losses in several countries in the world (Diaz-Montano *et al.,*

2011).

Purple blotch disease caused by *Alternaria porri* (Ellis) Cif. was ranked the second important pest after thrips (*Thrips tabaci*) in the study areas. Onion suffers from many diseases, such as leaf blight, downy mildew, white rot, neck rot, Fusarium basal rot and purple blotch (Biswas *et al.,* 2010). Among the foliar diseases, purple blotch is one of the most destructive diseases, commonly prevailing in almost all onion growing areas of the world except in very cool production areas which causes heavy loss under field conditions (Abubakar and Ado, 2009). *Alternaria porri* attacks both leaves and flower stalks (Bock, 1964) and greatly reduces foliar production (Suheri and Price, 2001). The disease has been reported to cause crop loss of 30% to 100% depending on prevailing weather conditions (Everts and Lacy, 1990). Onion purple blotch disease caused substantial loss of both bulb and seed yield in Bangladesh and other parts of the world where onions are famous crop (Meah and Khan, 1987; Rahman *et al.,* 1988; Pandotra, 1965). Onion purple blotch was listed as one of the major constraints in onion production by Mtaita and Msuya (1994) in Tanzania. *Alternaria porri* is a seed-born pathogen and infects all onion plant parts: leaves, floral parts and bulbs (Schwartz and Mohan, 2008). Onion debris serves as inocula sources. The pathogen spores can be spread in various fields by wind and splashing water; and over-season in and on infected crop debris (Schwartz and Mohan, 2008). According to Srivastava *et al.* (1994) a yield losses of 2.5 to 87.8% was reported in India.

The most common troublesome weed species reported in the study were Mexican poppy (*Argemone mexicana* L.) blackjack (*Bidens pilosa*), wild amaranth (*Amaranthus* spp.), star grass (*Cynodon* spp.) and other annual and perennial grasses. Mexican poppy weeds are worse when their seeds are mixed with onion seeds as it was observed from this study that farmers were producing their own seeds and sell among themselves and afar as the case of seeds from Lumuma to Msosa, Malolo B and Chabi villages. In Tanzania Seed Acts Number 18, its Regulation eighth schedule on prohibited, restricted and noxious weed seeds, Mexican poppy (*Argemone mexicana* L.) seeds are categorized in class 2 restricted noxious weed seeds (MAFC, 2007). According to this regulation the presence of restricted weed seed in any sample of seed shall be restricted. Where any restricted noxious weed seed are found in any sample of seed the maximum allowed shall not exceed four weed seed per kilogram. While majority of onion farmers were found to grow up to 2 acres, it has to be taken into consideration the seed rate of onion which is 1.4-2.3 kg/acre (3.5-5.5 kg/Ha). Therefore, the onion seeds packets are expected to be small-sized and certainly free from or up to 4 seeds per kg of Mexican poppy.

Conclusion

Since onion production was found to be the major source of livelihood to more than 80% of farmer respondents and that they had challenges like source of improved seeds, tactics to combat pests and higher yielding varieties which can resist insect pests and diseases, there is a need to carry out capacity building for community onion seed-based production. The IPM package on management of the most prevalent pests: thrips (*Thrips tabaci*), diseases such as purple blotch and weeds such as Mexican poppy (*Argemone mexicana*) is required to reduce onion yield losses. Although the onion farming community from the study area had three different varieties of onions, more best performing varieties in aspects of insect pests and diseases resistance and higher yielding varieties are required to increase productivity and to reduce poverty.

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References

Abubakar, L.and Ado, S. G. (2009). Genotype x Environmental reaction for resistance to purple blotch (*Alternaria porri* (Ellis) Cif.) in onion (*Allium cepa* L.) in Nigeria.Asian Journal of Crop Science. 1:15 – 25.

Agwu, A. E., Ekwueme,J. N.and Anyanwu,A. C.

(2008). Adoption of improved agricultural technologies disseminated via farmer radio programme by farmers in Enugu State, Nigeria. African Journal of Biotechnology 7(9): 1277-1286.

Agwu, A. E. and Anyanwu, A. C. (1996). Socio-cultural and environmental constraints in implementing the NALDA Programme in South Eastern Nigeria: A case study of Abia and Enugu States. Journal of Agriculture and Education 2: 68-72.

Anon. (1991). National Agricultural and Livestock Research Masterplan.Subject Matter Specialist Papers, Priority 1 and 2. Ministry of Agriculture, Livestock Development and Cooperatives, Dar es Salaam. pp. 466–471.

Biswas, S. K., Khair, A. and Sarker, P.K. (2009). Yield of onion and leaf purple blotch incidence as influenced by different level of irrigation. AgriculturaTropicaetSubtropica 43(2): 85 – 91.

Bock, K. R. (1964). Purple blotch (*Alternaria porri*) of onion in Kenya.Annals of Applied Biology 54:303 – 311.

Cramer, C. S. (2000). Breeding and genetics of Fusariumbasal rot resistance in onion. Euphytica115: 159 -166.

Diaz-Montano, J., Fuchs, M., Nault, B. A., Fail, J. and Shelton,A. M.(2011). Onion thrips (*Thysanoptera: Thripidae*): A global pest of increasing concern in onion. Journal of Economic Entomology 104(1): 1-13.

Everts, K. L. and Lacy, M. L. (1990). The influence of dew duration, relative humidity, and leaf senescence on conidial formation and infection of onion by *Alternaria porri.* Phytopathology 80: 1203-1207.

FAOSTAT. (2010).Food and agriculture commodities production. Food and agricultural organisation statistics. Available on http://faostat.foa.org/site/339/default.aspx. Visited 30th May, 2013.

FAO.(2000). Production Yearbook Vol. 54. Food and Agriculture Organization of the United Nations, Rome, Italy, 152 pp.

FAO. (2008). Food and Agriculture Organization Food production Year Book.

Kariuki, J. W. and Kimani, P. M. (1994). Yield and storage potential of onion cultivars in Kenya. In Proceedings of the 1st Eastern African Regional Alliums Workshop. (H. D. Rabinowitch, P. M. Kimani and R. Peters, eds.), pp. 50–56. Nairobi, Kenya, 21–22 Sept. 1994.

Meah, M. B. and Khan, A. A.(1987). Check list of fruit and vegetable diseases in Bangladesh. Dept. of Plant Pathology, BAU, Mymensingh, p. 23.

Ministry of Agriculture Food Security and Cooperatives (MAFC). (2003). The Seeds Act No. 18 of 2003. Rules and Procedures for Control of Quality Declared Seeds, 2007. 40pp.

Ministry of Agriculture Food Security and Cooperatives (MAFC). (2007). Tanzania National Seeds Regulations.2-13.

Mtaita, T. A. and Msuya, D. (1994). Current status of Allium production in Tanzania. Acta Horticulturae 358: 71-74.

Muendo, K. M. and Tschirley, D. (2004). Improving Kenya's domestic horticultural production and marketing system: current competitiveness, forces of change, and challenges for the future. Volume 1: Horticultural production. Working paper No. 08A/2004.

Narla, R. D., Muthomi, J. W., Gachu,S. M., Nderitu, J. H. and Olubayo, F. M. (2011). Effect of intercropping bulb onion and vegetables on purple blotch and downy mildew. Journal of Biological Sciences 11(1): 52-57.

Obinne, C. P. O. (1991). Adoption of improved cassava production technologies by small scale farmers in Bendel State. J. Agric. Sci. Technol. 1(1): 12-15.

Ozor, N. and Cynthia, N. (2010). Difficulties in adaptation to climate change by farmers in Enugu State, Nigeria. Journal of Agricultural Extension 14(2): 106-122.

Pathak, C. S. (2000). Hybrid seed production. Journal of New Seed 1: 89-108.

Pandotra, V. R. (1965). Purple blotch disease of onion in Punjab III-Control measures.Proc. Indian. Acad. Sciences 62(5): 229-343.

Rahman, M. L., Ahmed, H. U. and Mian, I. H. (1988). Efficacy of fungicides in controlling purple leaf blotch of onion, Bangladesh. J. Plant Path. 4 (1 and 2): 71–76.

Schwartz, H. F. and Mohan, S. K. (2008). Compendium of Onion and Garlic

Diseases and Pests. Pp 38-41. American Phytopathological Society.

Srivastava, M. M., Juneja, A., Dass, S., Srivastava, R., Srivastava, S., Mishra,S., Singh, V. and Prakash, S. (1994). Studies on the uptake of trivalent and hexavalent chromium by onion (*Aliumcepa*). Chemical Speciation Bioavailability 6: 27-30.

Suheri, H. and Price, T. V. (2001). The epidemiology of purple blotch on leeks in Victoria, Australia. European Journal of Plant Pathology 107: 503 – 510.

Waiganjo, M.M. (2012). Studies on the distribution, ecology and preventive management of thrips (*Thysanoptera: Thripidae*) on onions in Kenya. http://ir-library.ku.ac.ke/etd/handle/123456789/2858.Visited 15th July, 2013.

Waiganjo, M. M., Mueke, J. M., Gitonga, L. M. (2008). Susceptible onion growth stages for selective and economic protection from onion thrips infestation, pp. 193-200. In: R.K.P range and S. D. Bishop (eds.). Proceedings, Symposium: sustainability through integrated and organic horticulture. International symposium of the International Society for Horticultural Science (ISHS), 13-19 August 2006, Seoul Korea. Publication Acta Horticulturae. 767. International Society for Horticultural Science, Leuven, Belgium.