RESILIENT AGRICULTURE FOR IMPROVED NUTRITION

TRAINING ON INTEGRATED PEST MANAGEMENT

PRACTICAL MANUAL FOR FIELD STAFF

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People in Need CZECH REPUBLIC

20 YEARS PEOPLE IN NEED CZECH REPUBLIC AND GOING ON

LIST OF PRIORITY PESTS AND RELATED CROPS

#	List of pests in project area	Local name of the pest (Dinka)	Crops affected	Description
1.	African Bollworms 	Nyonyor	– Beans – Cowpea – Green gram – Okra – Peppers – Sorghum – Tomato	– Young caterpillars (larvae) are generally yellowish-white to reddish brown. – They have a dark brown to black head and several rows of black bumps with short hairs along their backs, which give them a spotted appearance. – Fully-grown caterpillars are 35 - 40 mm long.
2.	Aphids 		– Amaranth, Beans – Kale – Cowpea – Green gram – Groundnut, Okra – Peppers – Pumpkin – Sorghum – Spinach – Tomato	– **Nymphs** (immature stages) are young aphids; they look like the wingless adults but are smaller. – They become adults within 7 to 10 days. – **Adults** are small, 1 to 4 mm long, soft-bodied insects with two long antennas that resemble horns.
3.	Bagrada bug/Stink bug 	Mayen angeng	– Kale	– The adult is shield-shaped and green, tan, brown or gray in color. – Most of the adults are shiny, but other species are spiny and rough-textured. – Stinkbug emits a foul odor when disturbed, hence the name.

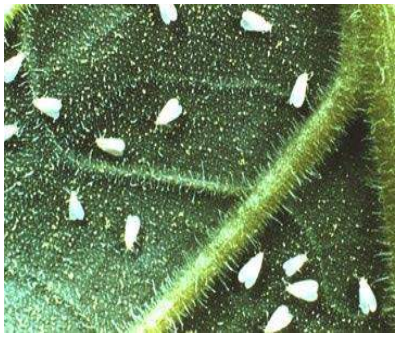
				
4.	Cabbage looper  	Nyant	– Kale – Tomato – Spinach	– **The caterpillars** go through five instars during development. – Very young caterpillars are white and almost clear with a black head capsule. – Older caterpillars are green with a thin white line on each side just above the spiracles and two other white lines on the dorsum. – Caterpillars have three pairs of legs near the head and three sets of prologs (false legs) near its rear. – They move in a "looping" manner, arching the middle portion of the body as they move forward. – Fully-grown caterpillars reach 3 to 4 cm in length.
5.	Cabbage moth	Nyant Marang	– Kale – Spinach	– The caterpillars are dark green with a light brown head and dark and yellowish white light stripes along the body.

				– These stripes are less visible when larvae are close to pupation. – They measure 1.6 to 2 cm in length when fully grown.
6.	Cabbage webworm 	Nyor Nyor	– Kale – Spinach	– The larva/caterpillar has dark-brown or black heads. – Its body is creamy-white with light pinkish-brown longitudinal stripes. – It is about 1.2 to 1.5 cm when fully grown.
7.	Cowpea seed beetle 	Arop	– Cowpea – Green gram – Pigeon pea	– **Adult beetles** are small, about 2 to 3 mm long and somewhat teardrop and slightly elongate. – They are pale to reddish brown with black and grey patches and two black spots near the middle on the wing cases. – The posterior part of the abdomen is not covered by the wing cases
8.	Cutworms 	Buluany	– Amaranth – Beans – Kale – Carrot – Eggplant – Maize – Okra – Peppers – Cowpea – Green gram – Sweet potato	– Young caterpillars are pale, yellowish-green with a blackish head. – Older caterpillars have a plump body; their colour varies from grey, dark green to brown or black with shiny, greasy-looking skin. – Fully-grown caterpillars are 4 to 5 cm long.

			– Sesame – Sorghum – Tomato	– Newly hatched caterpillars feed on the leaves and later on the stems. Older caterpillars feed at the base of plants or on roots or stems underground.
9.	Diamond Back Moth 	Nyan Thiu	– Kale – Spinach	– The adult is greyish brown with a nine mm long body and a wings 
10.	Fruit flies 	Aluang	– Avocados – Citrus plants, – Mango – Papaya – Peppers – Pumpkin – Watermelon	– Adult fruit flies are 4 to 7 mm long, brightly coloured, usually in brown-yellow patterns. – The wings are spotted or banded with yellow and brown margins
11.	Mealy bugs 	No Dinka name	– Amaranth – Beans – Kale – Okra – Onion – Peas – Peppers – Tomato	– Very small nymphs are flat, oval and yellow. – Older nymphs of some species are covered with fluffy, white wax.
12.	Leaf mining flies	No Dinka name	– Amaranth, – Beans – Kale – Okra – Onion – Cowpeas – Peppers	– Larvae are small yellow maggots (about 2 to 3 mm long when fully-grown). – They are found feeding inside the leaf tissue, leaving a long, slender,

			– Tomato	winding, white tunnel (mines) through the leaf. 
13.	Striga 	Dhiac	– Cowpea – Pigeon pea – Green gram – Sorghum	– Has purplish flowers – Parasitic weed
14.	Root Knot Nematodes  	No Dinka name	– Carrot – Cowpea – Okra – Peppers – Tomato	– Root-knot nematodes measure about 0.5 mm to 1.5 mm in length. – Juveniles (young nematodes) penetrate the root tips and occasionally invade roots in the zone of root elongation. – Invaded nematodes initiate the development of giant cells in the root tissues and galling of roots occurs.
15.	Giant East African Snail	Guak	– Kale – Groundnuts – Cowpea – Onion	– The adult giant African snail has a rounded-conical-shaped shell, about twice as high as its width. – It is brown in color with irregular darker streaks

				running transversely across its whorls. – When fully mature, its shell has 7-9 whorls
16.	Spider mites 	Ankor	– Amaranthus – Okra – Cowpeas – Tomato	– The adult is also very tiny, maybe yellowish, greenish, pinkish, or reddish depending on the species. – It looks like a tiny moving dot. It has an oval body with 8 legs and with 2 red eyespots near the head of the body. – The male is smaller than the female with a more pointed abdomen. – A female usually has a large, dark blotch on each side with numerous bristles covering her legs and body.
17.	Thrips 	No Dinka name	– Kale – Cowpea – Green gram – Okra – Onion – Tomato	– The adult has a slender small body, yellowish to dark-brown in color, and is cigar-shaped. – It is 1-2 mm long with a well-pronounced 5-8 segmented antennae. – It can exist in two forms, winged or wingless. – The winged form has two pairs of elongated narrow wings which are

				fringed with long hairs.
18.	White flies 	Uphar	– Kale – Green gram – Okra – Pigeon pea – Pumpkin – Tomato	– Pupae are dirty-white and surrounded by wax and honeydews. – During this stage, the red eyes of the emerging adults are visible. – Adults are about 1mm long with two pairs of white wings and light-yellow bodies. – Their bodies are covered with waxy powdery materials.

LIST OF PRIORITY DISEASES AND RELATED CROPS

#	List of diseases in project area	Crops affected	Symptoms
1.	Anthracnose 	– Beans – Citrus plants – Cowpea – Eggplant – Green gram – Mango – Onion – Peppers – Pumpkin – Sorghum – Spinach – Tomato – Watermelon.	– Anthracnose diseases attack all plant parts at any growth stage. The symptoms are most visible on leaves and ripe fruits. – At first, anthracnose generally appears on leaves as small and irregular yellow, brown, dark-brown or black spots. – The spots can expand and merge to cover the whole affected area. The colour of the infected part darkens as it ages. – The disease can also produce cankers on stems. Infected fruit has small, water-soaked, sunken, circular spots that may increase in size up to 1 cm in diameter. – As it ages, the center of an older spot becomes blackish and emits gelatinous pink spore masses.
2.	Bacterial wilt 	– Egg plant – Tomato – Peppers – Groundnut	– Growing points: wilting. – Leaves: wilting. – Roots: rot. – Stems: internal discoloration; creamy exudates; wilt. – Vegetative organs: internal discoloration. – Whole plant: plant death; dwarfing.
3.	Black rot 	– Kale – Pumpkin – Sweet potatoes	– Leaves: 'V' shaped lesions – Seeds: discolorations; lesions. – Stems: Internal discoloration (black in colour). – Vegetative organs: internal discolouration (black in colour); dry rot. – Whole plant: plant death.
4.	Damping off diseases	– Amaranth – Kale	– Leaves: lesions; abnormal colours; abnormal forms; wilting;

		– Carrot – Citrus plants – Cowpea – Green gram – Groundnut – Okra – Peppers – Sorghum – Tomato – Watermelon	fungal growth. – Roots: lesions. – Seeds: rot; discolorations. – Stems: external discolouration; canker; abnormal growth; mycelium visible. – Whole plant: plant death; dieback; damping-off.
5.	Downy Mildew 	– Kale – Millet – Onion – Pumpkin – Cowpea – Spinach – Watermelon	– Leaves: lesions; fungal growth. – Stems: fungal growth. – Flowers: fungal growth; flower abortion; flower drop. – Fruiting stage: fungal growth. 
6.	Early blight 	– Egg plant – Okra – Tomato	– Fruits/pods: spots. – Leaves: spots. – Stems: external discoloration.
7.	Fusarium wilt 	– Okra – Beans – Tomatoes – Green grams – Cowpea	– Okra: Leaves: yellowing lesions; abnormal colours. Whole plant: dwarfing. – Tomato: Leaves yellowing. Stems: internal discolouration. Whole plant: wilt. – Cowpea/Green gram/Beans: Leaves: yellowing; wilting.
8.	Late blight 	– Egg plant – Tomato	– Fruits: spots, unusual odour – Leaves: spots; abnormal colours; wilting; fungal growth. – Vegetative organs: leaf necrosis, dry rot. – Whole plant: seedling blight; leaf necrosis

9.	Powdery Mildew	– Carrot – Kale – Spinach – Pawpaw – Okra – Mango – Tomato – Water melon – Cowpea – Eggplant	– Powdery mildews are characterized by spots or patches of white to greyish, talcum-powder-like growth. – Tiny, pinhead-sized, spherical fruiting structures that are first white, later yellow-brown and finally black may be present singly or in a group. – These are the cleistothecia or over-seasoning bodies of the fungus. – The disease is most commonly observed on the upper sides of the leaves. – It also affects the lower sides of leaves, young stems, buds, flowers and young fruit. – Infected leaves may become distorted, turn yellow with small patches of green, and fall prematurely. Infected buds may fail to open.
10.	Tomato Yellow Leaf Curl Virus Disease (TYLCV) 	– Tomato – Beans	– Leaves: stunting, bushy growth; reduced size; abnormal forms. – Flowers: drop. – Stems: abnormal growth. – Whole plant: dwarfing.

IDENTIFICATION CHECKLIST FOR THE DIAGNOSIS OF PESTS AFFECTING PROJECT-SUPPORTED CROPS

#	List of pests in project area	Local names (Dinka)	Supported crops affected	Diagnosis	Proposed IPM solutions (specific methods to be used – certain solutions, mechanical measures, etc.)
1.	African Bollworms 	Nyonyor	– Cowpea – Green gram – Okra – Tomato	– At what stage of the lifecycle is it a pest: larvae/caterpillar, pupa or adult? **<u>larvae/caterpillar</u>** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Vegetative growing stage, flowering stage and fruiting stage.** – Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant? **Leaves, growing points, inflorescence and fruits/pods.** – What kind of damage does it cause: chewing, sucking or the death of	– Conserve natural enemies. The African bollworm has a wide variety of natural enemies. Parasitic wasps and predators such as ants, lacewings, and ladybird beetles are important in natural control of this pest. – Inspect plants regularly; once or twice a week after plants begins to bloom. Early detection of eggs and/or caterpillars before they bore into the pods is important. – Hand -pick and destroy eggs and caterpillars. This helps when their numbers are low and in small fields – Use neem extract to control African bollworm. – **Birds** that eat pests can be encouraged to visit crop fields. Some changes will encourage them to nest and stay in the

				the plant? **Caterpillars of the African bollworm feed on leaves, buds, growing points, flowers and fruit-chewing.** – When does it attack: dry season or wet season? **dry season**	area, and this can lead to a permanent increase in local predatory bird populations. – **Crop rotation:** Avoiding planting crops after each other that are susceptible to bollworm like sorghum, and tomato may help to reduce/prevent build up of bollworm populations. – Intercropping of tomato with onion is reported to divert the populations of sucking pests and the African bollworm
2.	Aphids 		– Kale – Cowpea – Green gram – Okra – Pumpkin – Spinach – Tomato	– At what stage of the lifecycle is it a pest: larvae/caterpillar, pupa or adult? **nymphs and adults** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Seedling stage, vegetative growing stage flowering stage and generative stage.** – Which part of the plant does it attack: leaves, roots, stem, fruits,	– Monitoring: It is particularly important to scout crops during the critical periods of seedling and shoot growth and during flowering and fruiting. To monitor aphid populations, examine the undersides of the leaves and the bud areas for groups or colonies of aphids. Presence of ants may indicate presence of aphids. Early detection of aphids is important as they can multiply rapidly. – Grow healthy plants. Healthy plants are able to protect

				seeds or the entire plant? **Growing points, stems, leaves, inflorescences, fruits and whole plant.** – What kind of damage does it cause: chewing, sucking or the death of the plant? **The aphids, both the nymphs and the adults, pierce the plant tissues to feed on plant sap. The leaf becomes severely distorted when the saliva of aphids are injected into it.** – When does it attack: dry season or wet season? **warm and dry season**	themselves better from pests and diseases than weak plants. Growers are strongly recommended to use compost in preference to manures, including liquid manures. – When transplanting, use aphid-free seedlings only, because often they are the source of infestation. Typically aphid populations introduced through transplanting are not evenly distributed in the field but rather form clusters of infestation. – Plant trap crops such as onions in vegetable crops – Avoid using heavy doses of highly soluble nitrogen fertilizers. Aphids love tender, juicy leaves. Instead apply fertilizer into 3 phases: during seeding, vegetative, and reproductive stages of plant growth. – Use an old soft brush or a used soft cotton cloth wetted with alcohol to remove aphids, – Prune damaged plant parts. – Sticky board traps: Aphids are attracted to yellow color. To

					make your own sticky trap, spread petroleum jelly or used motor oil on yellow painted plywood, 6 cm x 15 cm in size and up. Place traps near the plants but far apart enough to avoid leaves sticking to the board. – Water spray: Spray a steady stream of water on the host plant to knock-off aphids. Once on the ground, the fallen aphids are prey to ground predators and they have difficulty returning to the plant – Water traps: Half-fill yellow pan or basin with soapy water. Place the pan close to the plant but exposed enough so that aphids will see it. Trapped aphids sink and drown because soap breaks the surface tension of the water. The yellow color attracts the pests. However, if more beneficial insects are trapped, stop using this, as beneficial might be sufficient enough to control the pests. – Mix 2 teaspoons liquid

					soap/solution from bar soap with 4 liters of water .
3.	Bagrada bug/Stink bug  	Mayen angeng	– Kale	– At what stage of the lifecycle is it a pest: larvae/caterpillar, pupa or adult? **both adults and nymphs suck sap from leaves, which may wilt and later dry** – At what stage of plant growth does it attack: seedling, growing or mature plant? **seedling and vegetative/growing stage** – Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant**?** **leaves** – What kind of damage does it cause: chewing, sucking or the death of the plant? **sucking sap** – When does it attack: dry season or wet season? **Wet part of the season when plant growth stages ranged from pod formation to**	– **Monitoring:** To determine when control is necessary, shake the bugs out of the plant into a bucket of soapy water. Count the number of stink bugs. The economic threshold on soybean is 1 stink bug/row foot during the pod-fill stage. – For vegetables the suggested economic threshold for the red-banded stink bug is 24 insects/100 sweeps and 36 insects/100 sweeps for the brown stink bug. – Remove and control weeds from fields and also in the adjacent fields. Weeds serve as the pests' alternate hosts. – Plant small flowering plants to attract native parasitic wasps and flies. – Plough-under all plant debris after the harvest to destroy all possible breeding sites. – **Hand picking:** Handpicking and destruction of the bugs helps to reduce damage. This is particularly important in the

				<u>full seed development.</u>	early stages of the crop. Hand picking is only practical in small plots. – **Cultivation:** Eggs laid in the soil are readily killed by cultivation, so frequent light cultivation (once or twice a week) of the vegetable beds will help in controlling this pest – **Irrigation:** Watering and overhead irrigation disturb the bugs discouraging them from feeding on the crop. However, note that use of sprinkler irrigation may lead to increase of diseases such as black rot and downy mildew. – **Mixed cropping:** Growing strong smelling plants such as, onion near the crop is reported to reduce infestations. – **Plant extracts:** A mixture of chilli, soap, garlic and paraffin are an effective control method – **Natural products:** sprinkling the plants with crushed Bagrada bugs repels other bugs. This can be used effectively in combination with frequent soil cultivation. – **Soap solution:** Spraying plants

					with a soapy solution has been found effective against Bagrada bugs. It helps to wash off young bugs. – Encourage predators like African mantis found in Africa. – Avoid indiscriminate use of pesticides, for pesticides kill and reduce the numbers of praying mantids and other beneficial insects. – Maintain vegetation to provide natural habitats for the mantids. They also prey on Aphids, fruit flies, grasshoppers', caterpillars, and they eat each other when no food is available. – **Encourage predators like weaver ants:** This also prey on leaf-feeding caterpillars, aphids, citrus leaf miner, leafhoppers, plant hoppers, bugs, moths, adult black bugs, and small animals. Weaver ants thrive well in undisturbed places and plenty of green leaves
4.	Cabbage looper	Nyant	– Kale	– At what stage of the lifecycle is it a pest:	– **Monitoring:** Inspect plant regularly for the presence of

	 		– Tomato – Spinach	larvae/caterpillar, pupa or adult? **caterpillars/larvae feed primarily on leaves and cause irregular holes** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Vegetative growing stage.** – Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant**? Leaves and whole plant.** – What kind of damage does it cause: chewing, sucking or the death of the plant? **caterpillars eat small holes, but older caterpillars feed on the tissue between the veins skelotinising the leaves (leaving only the midribs and veins) or giving them a ragged appearance**	caterpillars, leaf damage and the presence of frass. Caterpillars can be detected by scouting the crop, while adults can be monitored by using light- or pheromone-baited traps. Monitor the presence of natural enemies. They play an important role in controlling the cabbage looper. Check plants twice a week once seedling emergence begins. When populations appear to be increasing, check more often. Treatment thresholds vary depending on the crop and location. Normally, spraying should not occur when there is less than 1 caterpillar per 5 plants. A control measure is not necessary unless you find more than 9 small to medium-sized caterpillars per plant – Remove and destroy all the plant debris after harvest. The pupae might still be in the plants. – Plough and harrow the field after harvest to expose pupae to sunlight and predators. – Clear the surrounding area of

				– When does it attack: dry season or wet season? **the cabbage looper is somewhat erratic in occurrence, typically very abundant one year and then scarce for two to three years**	weeds, which may serve as alternate hosts for the pests. – Spray the crop with a sugar-water solution to attract natural enemies when the pest is active. – Handpick the larvae and egg masses – Neem-based pesticides are reported to control the cabbage looper by interfering with the growth of young caterpillars. – Papaw leaf extract: 1 kg of papaya leaves, 10 liters of water, Mortar and pestle, Soap, Strainer and Pail.
5.	Cabbage moth 	Nyant Marang	– Kale – Spinach	– At what stage of the lifecycle is it a pest: larvae/caterpillar, pupa or adult? **caterpillar** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Flowering stage, fruiting stage, seedling stage and vegetative growing stage**. – Which part of the plant	– Intercropping cabbage with tomato, which acts as a repellent, can also reduce attack on cabbage. The cabbage crop is planted 30 days after tomato. – Remove the trap crops when these are heavily infested with the pests or else these pests will transfer to the main crop – Other important cultural practices include **field sanitation, crop rotation** and **intercropping.**

				does it attack: leaves, roots, stem, fruits, seeds or the entire plant**?** Fruits/pods, growing points, inflorescence an d leaves. – What kind of damage does it cause: chewing, sucking or the death of the plant? **Young caterpillars chew off top leaf surfaces. Older caterpillars feed under a web of silk on young leaves, petioles and growing points of the plant, often damaging it entirely, by eating most of the soft tissue leaving only the ticker veins (skeletonisation).** – When does it attack: dry season or wet season**? Dry cool seasons**	– Neem extracts give good control of the cabbage moth. –
6.	Cabbage webworm	Nyor Nyor	– Kale – Spinach	– At what stage of the lifecycle is it a pest:	– **Monitoring:** Regular monitoring of young plants in

				larvae/caterpillar, pupa or adult? **Young caterpillars mine the leaves while older caterpillars feed on the underside of rolled leaves within spun webs. Mature caterpillars (last instars) feed on leaves as well as stems and growing points.** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Flowering stage and vegetative growing stage.** – Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant**? Growing points, inflorescence, leaves, stems and whole plant.** – What kind of damage does it cause: chewing, sucking or the death of	the nursery and after transplant is important. Inspect crops for the presence of caterpillars and damage symptoms. – **Use clean planting materials**: transplant only healthy, vigorous insect-free seedlings. – **Field sanitation:** Uprooting and burning of cabbage and kale stalks and crop rotation are important to reduce field populations. – Cut off webbed leaves and kill the caterpillars inside. – Screen seedling beds when seedlings are about 15 cm high. See to it that the seedlings are growing vigorously – 1-2 kg of neem leaves, Mortar and pestle, used cotton cloth /sieve, Pot, Soap, Strainer, String. Pound neem leaves gently. Place in a pot/saucepan. Add 2-4 liters of water. Cover the mouth of the pot securely with the cloth and leave it as such for 3 days. Strain to get clear extract. Dilute 1 liter of neem leaf extract with 9 liters of water.

				the plant? **mining of leaves, feeding on stems and growing points** – When does it attack: dry season or wet season? **Dry cool seasons**	Add 100 ml of soap. Stir well. Spray on the infested plants. – Remove weeds that may serve as the alternate hosts surrounding your field. – Practice crop rotation with non-cruciferous crops – Conserve natural enemy like Diagema by planting flowering crops like tomatoes. Also parasitizes on Cabbage diamondback moth, potato tuber moth, cabbage webworm
7.	Cowpea seed beetle 	Arop	– Cowpea – Green gram	– At what stage of the lifecycle is it a pest: larvae/caterpillar, pupa or adult? **adults and larvae** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Fruiting stage and post-harvest.** – Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant**? Seeds.**	– Dry seeds for storage to a moisture level below 13%. – Intercropping: Intercropping maize with cowpeas, and not harvesting crops late significantly reduced infestation by several species of cowpea seed beetles – Sanitation: Good store hygiene plays an important role in limiting infestation by cowpea seed beetles. Remove infested residues from last season's harvest. General hygiene is also very important.

				– What kind of damage does it cause: chewing, sucking or the death of the plant**? Around 1 to 2 mm window is apparent at the location where the beetle is pupating**. – When does it attack: dry season or wet season? as **moisture levels starts to decline towards harvest**	– Sun-dry cowpea periodically in a thin layer for periods of up to 4 hours. – Farmers often mix cowpea grains with ash to control the cowpea seed beetle. To be efficient, it should be at least five percent of ash
8.	Cutworms  	Buluany	– Amaranth – Beans – Kale – Carrot – Eggplant – Maize – Okra – Peppers – Cowpea – Green gram – Sweet potato – Sesame – Sorghum – Tomato	– At what stage of the lifecycle is it a pest: larvae/caterpillar, pupa or adult? **caterpillar** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Seedling stage and vegetative growing stage.** – Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant? **Leaves, roots and stems.**	– **Monitoring:** To monitor for cutworm, count damage and freshly cut leaves, freshly cut young plants, and holes in leaves and in stems. Economic threshold level is 2-4% plants cut below the ground or 6-8% plants cut above the soil surface. Widely accepted threshold are 2, 3, 5, and 7 cut plants per 100 plants during seedling stage. – Soil traps: 1Mix equal quantities of hardwood sawdust, bran and molasses with enough water to make the mixture sticky. Spread around

				– What kind of damage does it cause: chewing, sucking or the death of the plant? **Caterpillars feed on leaves and later on stems.** – When does it attack: dry season or wet season? **damage is far more severe under very dry conditions and occurs deeper below the surface**	the plants in the evenings. The bait attracts the cutworms and as they try to pass through it they get stuck and die. – Removal of weeds in and around fields will reduce egg-laying sites and will help in the prevention of cutworm infestation. Do this at least 2-3 weeks before planting to reduce the incidence of cutworm larvae transferring to newly planted crops – Ploughing exposes caterpillars to predators and to desiccation by the sun. – Fields should be prepared and vegetation and weeds destroyed 10 to 14 days before planting the crop in the field. If the field is planted soon after land preparation some cutworms may be alive and attack the new crop – Delaying transplanting slightly until the stems are too wide for the cutworm to encircle and/or too hard for it to cut may reduce cutworm damage. – Hand picking of caterpillars at night by torch or very early

					morning before they return into the soil is useful at the beginning of the infestation. – Flooding of the field for a few days before sowing or transplanting can help kill cutworm caterpillars in the soil. – Experiments in Sudan showed that spraying aqueous neem seed and neem leaf extracts 3 times at weekly intervals, starting directly after tuberisation reduced early infestation by cutworms on potato leaves. To prepare the extracts, leaf and seed powder were soaked in water at a rate of 1kg/40 l of water, stirred thoroughly and left overnight, and passed through a sieve before spraying. – Ashes are reported to deter cutworms when spread on seedbeds, around plants, or mixed with the soil in the planting holes. The ash layer must be renewed repeatedly. – A thick dry stick inserted on the side of the seedlings can act as a mechanical barrier,

					reducing loss of plants by cutworms. –
9.	Diamond Back Moth 	Nyan Thiu	– Kale – Spinach	– At what stage of the lifecycle is it a pest: larvae/caterpillar, pupa or adult? **larvae/caterpillar** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Fruits/pods, growing points, inflorescence, leaves and stems.** – Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant? **Seedling stage, vegetative growing stage, flowering stage and fruiting stage**. – What kind of damage does it cause: chewing, sucking or the death of the plant? **DBM caterpillars feed as leaf miners inside the leaf tissue. older caterpillars feed on**	– Practice regular plant monitoring. The general economic threshold level is: in 60 randomly sampled plants with 1 larva found per plant, a recommended control measure is necessary. – Practice crop rotation. Do not plant members of the crucifer family (cabbage, broccoli, cauliflower) for 2 consecutive seasons on the same area to prevent serious damage from pests and diseases – Transplant only healthy seedlings, which are free of DBM eggs, caterpillars, and damage from other insects. – Plant affected crops on the beginning of rainy season. DBM activities are deterred by rain. – Use sprinkle irrigation in the late afternoon to limit the activity of adults. – Plough-under or remove and dispose all crop residues properly after harvest. This

				all plant parts- damage is called widowing – When does it attack: dry season or wet season? **dry months/seasons**	will disrupt any pest lifecycle. – Use of chilli extract: 12 pieces chopped hot chili, 200 grams fully dried and shelled neem seeds, 4 liters of water, Basin/pail, Grinder and Knife. – Maintaining natural surroundings, including trees and shrubs help to conserve natural enemies by providing shelter and plenty of breeding places for them. Maintaining strips of local flowering plants in the vicinity of the brassica crops is useful for beneficial insects. – Farmers in some countries produce their own homemade biopesticides by collecting diseased diamondback moth caterpillars (fat and white or yellowish or with fluffy mould on them), crushing them and mixing them with water in a blender. Large tissue clumps are filtered out and the liquid is sprayed onto the crop.
1(	Fruit flies	Aluang	– Pumpkin	– At what stage of the lifecycle is it a pest: larvae/caterpillar, pupa	– Destroy all infested fruit. – Wrap or bag individual fruits with newspaper or paper bags

				or adult? **adult and maggots** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Fruiting stage.** – Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant? **Fruits/pods.** – What kind of damage does it cause: chewing, sucking or the death of the plant? **Fruit flies cause direct damage by puncturing the fruit skin to lay eggs and maggots feed on the fruit flesh making galleries.** – When does it attack: dry season or wet season? **climate has weak associative relationship with fruit fly population**	to prevent fruit flies from laying eggs on the fruit. Wrapping or bagging should be started shortly after fruit set. – Frequent applications of neem can keep fruit fly attack to a minimum.
1	Mealy bugs	No Dinka name	– Amaranth	– At what stage of the lifecycle is it a pest:	– Practice proper sanitation. Clean tools after used. Avoid

			– Beans – Kale – Okra – Onion – Peas – Peppers – Tomato	larvae/caterpillar, pupa or adult? **Adult** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Growing points, leaves, roots, stems and whole plant**. – Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant? **Seedling stage, vegetative growing stage, flowering stage and fruiting stage.** – What kind of damage does it cause: chewing, sucking or the death of the plant? **mealy bugs damage plants by sucking sap from roots, tender leaves, petioles and fruit** – When does it attack: dry season or wet season? n/a	movements of working animals and yourself from infested to non-infested areas the same day. Mealy bugs can be transported from one area to another through farm tools and equipments, trellis materials, plant parts, and working animals – Infested plants and plant parts should not be used as mulch. These should be removed from fields and destroyed – Control and kill ants. Flood and plow the fields. This will destroy ant colonies and expose eggs and larvae to predators and sunlight. Ants use mealy bugs to gain access to nutrients from the plants – Avoid using heavy doses of highly soluble nitrogen fertilizers since mealy bugs, like other sap-feeding insects, love tender-juicy leaves. – Orange peel spray or any peel from citrus fruits. To prepare: Pour 2 cups of boiling water on the peel of 1 orange. Let it stand for a day. Strain, add few drops of soap, and spray to

					infested plant parts. – Spray a steady stream of water (reasonably high pressure) on the host plant to knock-off mealy bugs. Once on the ground, the fallen ones will be available to ground predators and this will also make their return to the plant difficult. Wetting mealy bugs encourages fungal pathogens that may infest on them – Handpicking Rub or handpick mealy bugs from affected plants to reduce populations. They release chemicals that signal others to drop and leave. – Pruning Prune affected plant parts to remove mealy bugs. Remove and destroy heavily infested plant. This will cut down sites and reduce future populations. – Rubbing alcohol dipped in cotton swab can kill visible mealy bugs. Alcohol dissolves the wax around the insects and their eggs and kills them. However, this control measure is not adequate when infestation is high and the area

					is big
11	Leaf mining flies 	No Dinka name	– Amaranth – Kale – Okra – Onion – Cowpeas – Tomato	– At what stage of the lifecycle is it a pest: larvae/caterpillar, pupa or adult? **adults and maggots** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Seedling and vegetative growing, flowering and fruiting stages.** – Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant? **Leaves and pods.** – What kind of damage does it cause: chewing, sucking or the death of the plant? **Female flies puncture leaves and in some instances also fruits/pods (e.g. cowpeas) with their ovipositor to feed and to lay eggs. maggots feeding in the plant tissue**	– Plastic trays placed under the plants to monitor and catch pupating larvae as they leave the plants to pupate in the soil – An inverted kitchen funnel capped with a plastic vial to monitor adults' emergence from the seedbeds – Sticky board traps: To make your own sticky trap, spread petroleum jelly or used motor oil on yellow painted plywood, 6 cm x 15 cm in size or up. Place traps near the plants but faraway enough to prevent the leaves from sticking to the board – Conservation of the natural enemies is an important aspect of leaf miner management. Maintain flowering grasses around field margins to provide habitat and food for natural enemies. – Proper field sanitation. Remove and burn all crop residues after harvests. Burning is very effective to prevent emergence of eggs and larvae remaining in the leaves

				– When does it attack: dry season or wet season? n/a	– Plow-under remaining plant residues, to expose pupae to ground predators, and to sunlight. Flooding the field is another method to kill the pupae. – Practice crop rotation or grow different crops in one season. – Plant resistant varieties, transplant only non-infested seedlings. – Immediately remove and destroy any leaf miner infested leaves. Do not put infested leaves in compost. – Hand-picking and destroying of mined leaves. – Destroying all infested leaves and other plant material after harvest – **Neem-based pesticides** are used for control of leaf mining flies. Neem products reduce fecundity and longevity of flies and disrupt the development of the maggots. They can be applied as drench or as foliar sprays
1	Striga	Dhiac	– Cowpea	– At what stage of the	– It requires a combinations of

			– Pigeon pea – Green gram	lifecycle is it a pest: larvae/caterpillar, pupa or adult? **adult** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Flowering stage, fruiting stage, pre-emergence, seedling stage and vegetative growing stage.** – Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant? **Leaves, stems and whole plant.** – What kind of damage does it cause: chewing, sucking or the death of the plant? – When does it attack: **dry season or wet season? dry conditions**	rotation, varietal selection, soil fertility enhancement and intercropping with legumes, supplemented in all cases by hand-pulling. – Hoeing and hand weeding before Striga plants start to flower. Late weeding requires the burning of collected plants to kill the seeds. Never put them in your compost pile or pit. – Regular plant monitoring – Proper seed selection Use seeds that are Striga seeds-free. – Avoid using seeds from the previous harvest if the crops were infested with Striga. Buy the seeds for your next cropping from an agricultural seed store in your locality
1	Root Knot Nematodes	No Dinka name	– Carrot – Cowpea – Okra – Peppers	– At what stage of the lifecycle is it a pest: larvae/caterpillar, pupa or adult? **juvenile young nematodes**	– Do not locate seedbeds where vegetables have been grown previously. After preparation of the seedbed, burn the topsoil using dry leaves or other waste

	 		– Tomato	– At what stage of plant growth does it attack: seedling, growing or mature plant? **all growth stages** – Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant? **roots, leaves, the whole plant** – What kind of damage does it cause: chewing, sucking or the death of the plant? **Show the adults, but mostly they are not seen with the naked infected plants have swollen, impaired roots. Nematode's feeding stimulates the production of galls (root knots). Galls are found on the root system both on the primary and secondary roots. Their sizes vary from .02 to 20 cm in diameter.**	plant material. – Solarise seedbeds if possible. – Maintain high levels of organic matter (manure and compost) in the soil. – Incorporate neem cake powder into the soil if it is available. – Use of organic fertilizer particularly the chicken dung – Grow healthy plants Regular and timely weeding – Fields should be ploughed deep and the followed by a dry fallow. – Uproot entire plants from the field after harvest and destroy crop debris. – Tomato varieties carrying 'VFN' label are tolerant to root-knot nematodes. Most of these varieties are commercially available in the region. – Garlic extract, ash

				The gall is characterized by smaller swellings and more uniformly distributed infection on the lateral feeding roots. Inside the gall are shiny white bodies of the female nematodes (about the size of a pinhead). At the root surface, shiny white to yellow egg masses are found. a closer look with a magnifier may eye. – When does it attack: dry season or wet season? **Warm temperature and moist but well-aerated sandy soil.**	
1	Giant East African Snail	Guak	– Kale – Cowpea – Onion	– At what stage of the lifecycle is it a pest: larvae/caterpillar, pupa or adult? **adult** – At what stage of plant growth does it attack: seedling, growing or mature plant? **seedling**	– Practice good field sanitation. – Monitor regularly for the pest in the nursery and in the field. – In East Africa, sprinkling their habitats and / or around crop base with table salt in dry seasons, has proven effective in their control.

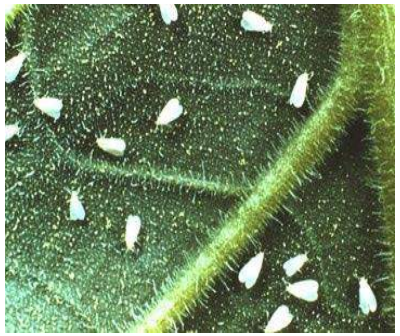
				**stage, vegetative stage and fruiting stage** – Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant? **leaves and fruits** – What kind of damage does it cause: chewing, sucking or the death of the plant? **Snails feed on seedlings, soft plant parts, ripening fruit that are close to the soil, and organic matter. Their feeding damage is irregular large holes on leaves but they can consume the young seedlings completely.** – When does it attack: dry season or wet season? **wet seasons**	– Brewers' waste in water containers is effective trap. They are attracted by the yeast and they get drowned when going for the brew. – International quarantine and surveillance activities. – Hand collection. – Food baits (e.g. over-ripe papaya fruit pieces). However, these baits should be daily removed from orchards and destroyed. – Plant ash, saw dusts, sand, D.E. or eggshells. – Sprinkle enough ash, sand, or crushed eggshells at the base of the plants. The snails are sensitive to harsh objects which prevent them from crawling into the plants. Remember to keep these substances dry to be effective. But make sure that your control method is not a waste of time because snails are problematic only when the soil is moist.

1(	Spider mites 	Ankor	– Amaranthus – Okra – Cowpeas – Tomato	• At what stage of the lifecycle is it a pest: larvae/caterpillar, pupa or adult? **adult** • At what stage of plant growth does it attack: seedling, growing or mature plant? **vegetative growing stage, flowering** • Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant? **Leaves, inflorescences, fruits.** • What kind of damage does it cause: chewing, sucking or the death of the plant? **sucking to remove plant sap** • When does it attack: dry season or wet season? n/a	– Inspecting your field regularly is very important, since the population build up of the mites is very rapid. At the beginning of the infestation the distribution of mites is very patchy. Control must start early. It is very difficult to control the mite population once they are established. A recommended monitoring method for mites on tomato is: – Select randomly 20 tomato plants and access the level of damage caused by the mites of 3 leaflets/plant by using a damage leaf index ranking from 1 to 5 (1 is few yellow spots, 5 is leaf totally covered with spots, dry patches occur). Once the average damage level exceeds the first rank, control measures should start – Close inspection of the underside of affected leaves shows mites as tiny moving specks (red or yellow-greenish depending on the species) and whitish particles (shed skins of mites). – Site nurseries away from

					infested crops and avoid planting next to infested fields. – Grow healthy crops; avoid water and nutrient stress. Apply mulch and incorporate organic matter into the soil to improve the water holding capacity and reduce evaporation. – Keep perennial hedges such as pigeon peas, they are said to encourage a predatory mites, which predate on spider mites. – Uproot and burn infested plants. This can be successful during the early stages of infestation when the mites concentrate on a few plants. – Keep the field free of weeds. – Remove and burn infested crop residues immediately after harvest – Mites favour dry and hot conditions. Influencing the microclimate by reducing the planting distance is reported to suppress spider mite populations. However, this could also enhance fungal diseases, so care should be taken.

					– When moving through the crop for weeding, pruning, harvesting or any other field work, always leave the infested area until last in order to minimise the spread of mites on clothing or farm tools – Neem products, in particular oil formulations give reasonable control of spider mites. Though neem does have some systemic effect in plants, spray it as other contact insecticides, ensuring thorough spray coverage and targeting the undersides of the leaves where spider mites tend to cluster. – **Soap spray:** Apply on the infested plants thoroughly, including the undersides of the leaves. Spray early in the morning or late afternoon. Precaution: Soap spray may injure foliage. Test these sprays on few leaves before applying to the entire field. It may take 2 days for damage – Provide plants with adequate water. Water-stressed plants are prone to damage by mites

					– Remove weeds also on field margins and irrigation ditches. – Avoid the use of broad spectrum insecticide for this may cause a mites' outbreak. This practice kills the natural enemies of mites and stimulates mites' reproduction
1'	Thrips 	No Dinka name	– Kale – Cowpea – Green gram – Okra – Onion – Tomato	– At what stage of the lifecycle is it a pest: larvae/caterpillar, pupa or adult? **adults** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Flowering stage, post-harvest, seedling stage and vegetative growing stage.** – Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant**? Growing points, inflorescence and leaves.** – What kind of damage	– To monitor for thrips, shake leaves and flowers gently onto a white sheet of paper or into a shallow carton box. The general recommended economic threshold level is: 20% of the plant population is infested with thrips. Count the number of plants with thrips and not the actual number of thrips – Prune off and remove heavily infested plant parts. – Remove weeds as the thrips population builds-up on them. – Crops which are sensitive to thrips attack should not be planted following onions. Volunteer onion plants that attract thrips should be

				does it cause: chewing, sucking or the death of the plant**? Piercing the plant tissue and sucking up the released plant juices.** – When does it attack: dry season or wet season? n/a –	removed. – Collect thrips by gently shaking leaves and flowers onto a white sheet of paper or into a shallow cartoon box. – Bright blue or royal blue sticky traps. Thrips are attracted to these colors. To make your own sticky trap, spread petroleum jelly or used motor oil on a blue shade painted plywood, 6 cm x 15 cm or up in size. Place traps near the plants with enough distance that the leaves from sticking to the board. The traps when hung should be positioned at a 60-75 cm zone above the plants.
1	White flies 	Uphar	– Kale – Green gram – Okra – Pumpkin – Tomato	– At what stage of the lifecycle is it a pest: larvae/caterpillar, pupa or adult? **adult** – At what stage of plant growth does it attack: seedling, growing or mature plant? **seedling, vegetative growing and flowering stage**	– To monitor the presence of whiteflies, look at the underside of the leaves to see the tiny eggs, larvae, and the adults. Shaking the plants gently would disturb the adult whiteflies and they will fly off. If there is an incidence of whitefly infestation, prompt control is necessary as whiteflies multiply their

				– Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant**? Leaves.** – What kind of damage does it cause: chewing, sucking or the death of the plant**? sucking plant sap and removing plant nutrients, thereby weakening the plants** – When does it attack: dry season or wet season? **n/a**	numbers rapidly – Do not plant crops such as tomato, eggplant, cucumber, pepper, cole crops, and cotton near crops that have whitefly infestation. This would lead to early infestation of these crops and could ruin the whole field crop. – Plant susceptible crops at least one-half mile upwind from other whitefly hosts crops. – Even after the crops have been harvested, the whiteflies continue to live on the abandoned crop residues. To stop the lifecycle, plow the field immediately after harvest and incorporate the plant debris into the soil. – Remove and destroy any whitefly infested plants. – Whiteflies are attracted to Nicotiana, a flowering tobacco plant variety. Plant this crop as trap crop – Sticky board traps. Traps give early warning and serve as natural control method. – To use, place 1 to 4 yellow

					sticky cards per 300 square meter field area. Replace traps at least once a week. It is difficult to determine the population of newly trapped whiteflies on a sticky card to those previously trapped ones. – To make your own sticky trap, spread petroleum jelly or used motor oil on yellow painted plywood, 6 cm x 15 cm in size or above

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IDENTIFICATION CHECKLIST FOR THE DIAGNOSIS OF DISEASES AFFECTING PROJECT-SUPPORTED CROPS

#	List of diseases in project area	Crops affected	diagnosis	Proposed IPM solutions (specific methods to be used – certain solutions, mechanical measures, etc.)
1.	Anthracnose 	– Beans – Citrus plants – Cowpea – Eggplant – Green gram – Mango – Onion – Peppers – Pumpkin – Sorghum – Spinach – Tomato – Watermelon.	– What is the cause of the disease: virus, bacteria or fungus? **fungus** – How is the disease transmitted: by seeds, through the soil, by air or by insects? **insects, air currents/wind and contact** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Flowering stage, fruiting stage, post-harvest, seedling stage, and vegetative growing stage.** – Which plant part is attacked: leaves, roots, stem, fruits, seeds or the entire plant? **Leaves, stems,**	– Use certified disease-free seeds. Anthracnose is seed-borne. 2. Properly select healthy plants for transplanting. – Keep weeds under control at all times. Keep the surroundings of your farm free of weeds, unless they are maintained and intended as habitat for natural enemies. – Make yourself 'clean'. Always bear in mind that you might be the carrier of the diseases while you move from one plant to another – Pull out plants that are heavily infected. – Prune the plant parts of fruit trees that show severe symptoms of disease infection. – Properly dispose of all the infected plants. – Pick rotten fruits and collect those that have dropped and bury in a pit.

			fruits/pods, and inflorescence.	– If possible, remove all the crop residues after harvest. Add these to your compost pile. – Plough-under the crop residues and organic mulches. This improves soil condition and helps to disrupt the disease lifecycle. – Maintain cleanliness on the irrigation canals – Make your own compost. Your compost pile is where you can place your plant trimmings and other plant debris. – Clean your farm tools. Wash ploughs, harrows, shovels, trowels and pruning gears after use. Lightly oil pruning gears. – Remove and destroy infected parts but avoid touching other plant parts, especially when these are wet – Harvest unripe but mature fruits – Baking soda spray – Bordeaux mix spray – When using own seed, treat the seed with hot water.
2.	Bacterial wilt 	– Egg plant – Tomato – Peppers – Groundnut	– What is the cause of the disease: virus, bacteria or fungus? **bacteria** – How is the disease transmitted: by seeds, through the soil, by air	– Remove and destroy all infected plants immediately – Control nematodes – Rotate crops other than solanaceous crops. Rice, corn, beans, cabbage, and sugarcane are found to be resistant to bacterial wilt

			or by insects? **vegetative propagation material, soil pests and infected crop residues left in the field, running water, infected soil, infected seedlings** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Vegetative growing stage.** – Which plant part is attacked: leaves, roots, stem, fruits, seeds or the entire plant? **Leaves, roots, seeds, fruits, stems, vegetative organs and whole plant.** – What kind of damage does it cause: rotting, chlorosis, wilting, spots, etc.? – **Growing points: wilting.** – **Leaves: wilting.** – **Roots: rot.**	– Since the bacteria can be transmitted through farm tools, wash or expose them to heat before using in another field – Do not grow crops in soil where bacterial wilt has occurred. – Rogue out wilted plants from the field to reduce spread of the disease from plant to plant – Control root-knot nematodes since they could facilitate infection and spread of bacterial wilt – Where feasible, extended flooding (for at least 6 months) of the infested fields can reduce disease levels in the soil – Soil amendments (organic manures) can suppress bacterial wilt pathogen in the soil

			– **Stems: internal discoloration; creamy exudates; wilt.** – **Vegetative organs: internal discoloration.** – **Whole plant: plant death; dwarfing.** – When does it attack: in the dry season or the wet season? **Bacterial wilt is very destructive especially during hot and wet seasons.**	
3.	Black rot 	– Kale – Pumpkin – Sweet potatoes	– What is the cause of the disease: virus, bacteria or fungus? **bacteria** – How is the disease transmitted: by seeds, through the soil, by air or by insects? **In a new field, black rot is usually introduced via infected seed or diseased transplants. Further spread is facilitated by water-splash,**	– Use certified disease-free seed. – Establish crops in seedbeds in black rot-free soils that have not grown crops from the family Crucifers for at least 3 years. – Seedlings should not be crowded in the nursery. – Transplants should not be dipped in water before transplanting. – Mulching of the field crop, where practicable, is highly recommended. – Avoid wet, poorly-drained soils – Avoid overhead irrigation. – Field operations during wet weather should be discouraged

			running water, and handling infected plants. – At what stage of plant growth does it attack: seedling, growing or mature plant? **Seedling stage, vegetative growing stage and heading stage (cabbages).** – Which plant part is attacked: leaves, roots, stem, fruits, seeds or the entire plant? **Leaves, seeds, stems, vegetative organs and whole plant.** – What kind of damage does it cause: rotting, chlorosis, wilting, spots, etc.? – **Leaves: 'v' shaped lesions** – **Seeds: discolorations; lesions.** – **Stems: internal discoloration (black in colour).** – **Vegetative**	– Keep the field free of weeds, particularly of the crucifer family. – Growing cabbage on raised beds helps eliminate conditions that induce black rot. – When possible, remove, burn, or plough down all crop debris immediately after harvest to reduce the amount of bacteria in the soil – A crop rotation based on at least a 2-year break in cruciferous crops is advocated. – Use of resistant/tolerant varieties, where commercially available, provides the most effective control of the disease. – Hot water treatment

			organs: internal discolouration (black in colour); dry rot. – **Whole plant: plant death** – When does it attack: in the dry season or the wet season? **warm wet conditions**	
4.	Damping off diseases 	– Amaranth – Kale – Carrot – Citrus plants – Cowpea – Green gram – Groundnut – Okra – Peppers – Sorghum – Tomato – Watermelon	– What is the cause of the disease: virus, bacteria or fungus? **fungus** – How is the disease transmitted: by seeds, through the soil, by air or by insects? **spread of damping-off fungi depends primarily on the mechanical transfer of mycelia, sclerotia or resting spores in infested soil particles (on flats, tools, baskets or end of the watering hose) or infected plant tissue.** – At what stage of plant growth does it	– Good seedbed management. – Avoid fields with a history of the disease. – Practice crop rotation. – Deeply plough fields. – Use certified disease-free seeds. If using own seed, hot water treatment can be used. – Solarisation of seedbeds should be done where feasible. – Thin the seedlings in seedbeds to permit good air circulation. – Avoid excessive watering and fertilization, particularly with nitrate. – Plant on raised beds to reduce moisture content in the root zone and provide the appropriate drainage in the field to prevent waterlogged conditions. – Schedule planting times to avoid temperature and moisture conditions that are conducive to the pathogen. It

			attack: seedling, growing or mature plant? **Heading stage (in cabbage), post-harvest (in cabbage), pre-emergence, seedling stage and vegetative growing stage.** – Which plant part is attacked: leaves, roots, stem, fruits, seeds or the entire plant? **Leaves, roots, seeds, stems and whole plant.** – What kind of damage does it cause: rotting, chlorosis, wilting, spots, etc.? – **Leaves: lesions; abnormal colours; abnormal forms; wilting; fungal growth.** – **Roots: lesions.** – **Seeds: rot; discolorations.** – **Stems: external discolouration; canke**	also will reduce disease severity. – As free water is important for distribution and development of the diseases, efforts to reduce soil moisture will help to reduce disease severity. – Tomatoes: The seedbed should not be sited on a field previously planted with eggplant, pepper, potatoes, tomatoes or other related crops. Do not site the seedbed next or near to tomato production fields. The seedbed should preferably be up-wind to tomato fields. – Okra: Avoid fields previously planted with cotton or other related crops.

			r; abnormal growth; mycelium visible. – **Whole plant: plant death; dieback; damping-off.** – When does it attack: in the dry season or the wet season? **wet season/excessive soil moisture**	
5.	Downy Mildew 	– Kale – Millet – Onion – Pumpkin – Cowpea – Spinach – Watermelon	– What is the cause of the disease: virus, bacteria or fungus? **fungus** – How is the disease transmitted: by seeds, through the soil, by air or by insects? **spread through fields** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Seedling stage, vegetative growing stage, flowering stage and fruiting stage.** – Which plant part is attacked: leaves, roots, stem, fruits, seeds or	– Use resistant varieties where available – Use only certified diseased-free seeds for sowing. Transplant only healthy seedlings. – Ensure proper land preparation to make sure that your soil is well drained. – Provide adequate plant spacing to reduce the density of the canopy and minimise humidity. – Pruning of new growth also helps proper plant's aeration. – Remove infected plants and prune infected shoots. – Properly dispose of collected diseased-parts either by burning or burying them. – Avoid overhead watering. It lengthens the duration of leaf

			the entire plant? **leaves and the whole plant** – What kind of damage does it cause: rotting, chlorosis, wilting, spots, etc.? – **Leaves: lesions; fungal growth.** – **Stems: fungal growth.** – **Flowers: fungal growth; flower abortion; flower drop.** – **Fruiting stage: fungal growth.** – When does it attack: in the dry season or the wet season? **It spreads rapidly through fields and is dependent on a wet, humid environment with cool or warm, but not hot, temperatures.**	wetness and favours further development of the disease. – Plough-under all the plant debris after harvest. – Practice crop rotation. – Seedbeds should have well-drained soils and be sited away from hedges and windbreaks. The site should not have been under susceptible crops for at least the previous 2 years. – Seedlings should not be excessively watered. – Weeds should be eradicated in and near seedbeds and out in the production fields. – Crop residues should be removed from the field after harvest. – Avoid sprinkler irrigation. – Thin plants to reduce plant density and increase air movement. – Time irrigations so that they do not elongate leaf wetness. – Alter planting dates to avoid periods of high disease pressure – Use of copper fungicides – Bordeaux mixture – **Hot water treatment** – Hot water treatment on seeds helps reduce the seed borne pathogens that cause diseases on plants. However, the specified

				temperature and time interval should be strictly followed in order to keep the effectiveness of the seeds to germinate. Use a good thermometer or better ask for assistance from qualified personnel from your local agriculturist office. **Procedure** – In a large pot put plenty of water. – Heat the water following the required temperature. – Place seeds in loose cotton bag and submerge it in water. Follow strictly the recommended temperature and the time interval required. It is important that the water is maintained at a uniform temperature throughout the container. – Constantly stir the water while soaking the bag. – Suspend the bag- do not let it touch the bottom of the pot. – Remove the bag and emerge it in cold water to quickly stop the heating. – Spread the seeds to cool and dry. – Do not store treated seeds. Sow them on well-prepared seedbeds. **Heat treatment recommendations** – Cabbage, eggplant, tomato, spinach - 122°F/50°C: 25 minutes

				– Pepper - 125°F/51.6°C: 30 minutes – Tomato - 125°F/51.6°C: 30 minutes – Eggplant - 122°F/50°C: 30 minutes – Carrots - 118°F/47.7°C: 20 minutes **<u>Bleach solution</u>** – Mix 1 part of bleach to 9 parts of water – Place the seeds on a small cotton bag – Dip the bag into the bleach solution – Dry dipped seeds on old newspapers and make sure that seeds are completely dry before storing
6.	Early blight 	– Egg plant – Okra – Tomato	– What is the cause of the disease: virus, bacteria or fungus? **fungus** – How is the disease transmitted: by seeds, through the soil, by air or by insects? **Early blight can be seed-borne, resulting in damping-off. Infected plant residues in the soil can carry the disease to the following season, particularly if the soil is dry.**	– Remove weeds as these may serve as the alternate hosts. – Practice the recommended plant spacing to promote good air circulation. – Minimize injury to the tubers during harvesting and handling. – Plough under all the crop residues after harvest to physically remove the spore source from the topsoil. – Use of copper fungicides – **Onion bulb extract:** Ingredients: 50 g of bulb onion and 1 litre distilled water. Finely chop the onion. Add to water. Mix well. Strain. Spray thoroughly on the infected plant, preferably early in the morning or

			– At what stage of plant growth does it attack: seedling, growing or mature plant? **affected plant stages all growth stages** – Which plant part is attacked: leaves, roots, stem, fruits, seeds or the entire plant? **whole plant except the roots** – What kind of damage does it cause: rotting, chlorosis, wilting, spots, etc.? – **Fruits/pods: spots.** – **Leaves: spots.** – **Stems: external discoloration.** – When does it attack: in the dry season or the wet season? **it is of particular importance in warm dry areas.**	late afternoon – **Hot water treatment of seeds: Hot** water treatment of seeds, where own seeds are used, could help reduce the incidence of seed-borne infection by early blight. It will also take care of other seed-borne problems caused by pathogens such as Phoma spp., Septoria spp. and bacterial pathogens. Specified temperatures and recommended time for treatment should be strictly followed in order to maintain seed viability. Use a good thermometer or better ask for assistance from qualified personnel from your local extension office. To make sure that the seed is not damaged it is advisable to test the germination of 100 heat-treated and 100 untreated seeds.
7.	Fusarium wilt	– Okra – Beans – Tomatoes	– What is the cause of the disease: virus, bacteria or fungus?	– Plant wilt-resistant cultivars whenever possible. Ask for assistance from your local agriculturist office.

		– Green grams – Cowpea	**fungus** – How is the disease transmitted: by seeds, through the soil, by air or by insects? **it can spread by movement of infested soil or infected transplants.** – At what stage of plant growth does it attack: seedling, growing or mature plant? **seedling but mostly during reproductive stage** – Which plant part is attacked: leaves, roots, stem, fruits, seeds or the entire plant? – **Okra: seedling stage and vegetative growing stage.** – **Tomato: flowering stage, fruiting stage and seedling stage.** – **Cowpea/beans: vegetative growing stage.** – What kind of damage does it cause:	– Practice a proper crop rotation strategy. If your soil is severely infested, planting solanaceous and other susceptible crops is not advisable. – Whenever practical, remove and destroy infested plant materials after harvest. However, do not put these into your compost pit or pile. Compost from such materials will contain the fungi. – Grow healthy plants with appropriate fertilization, irrigation, and weed control. – Because *Fusarium* persist several years in soil, a long crop rotation (4 to 6 years) is necessary. – Avoid using any solanaceous crop (potato, tomato, pepper, eggplant) or other host plants in the rotation. Rotate with cereals and grasses wherever possible. – Avoid fields with a long history of *Fusarium* wilt. – Deeply plough the fields and leave them fallow for 2-3 months, where feasible – Use certified, disease-free seeds – Use resistant varieties, e.g. tomatoes: 'Diego', 'Duke', 'Floridade', 'Fanny', 'Fortune Maker', 'Napoli', 'Radja', 'Roma VF', 'Roma VFN' and

			rotting, chlorosis, wilting, spots, etc.? – **Tomato: leaves yellowing. Stems: internal discolouration.** – **Whole plant: wilt.** – **Beans: leaves: yellowing; wilting.** – **Okra: leaves: yellowing lesions; abnormal colours. Whole plant: dwarfing.** – When does it attack: in the dry season or the wet season? **high soil temperature/soil moisture stress**	'Tengeru 97'. Graft tomato plants on resistant root stocks where available. – Raise soil pH by applying lime or farmyard manure where soil is acidic. Do not use chicken manure, which is very acidic. – Control root-knot nematodes. – Keep fields weed-free – Regularly irrigate the crop
8.	Late blight 	– Egg plant – Tomato	– What is the cause of the disease: virus, bacteria or fungus? **fungus** – How is the disease transmitted: by seeds, through the soil, by air or by insects? **Spores are the mechanism for the rapid and devastating spread of**	– Controlling blight once it has taken over is very difficult. The most important way of controlling late blight is to **prevent its spread**. At this point, there is no biological control of known efficacy for use in suppressing late blight. – **Cultural techniques** can help to reduce the risk of late blight outbreaks. – Stake tomato plants to keep them

			late blight when conditions are cool and moist. Splashes of water can transfer the spores from plant to plant and wind can carry the spores' greater distances. – At what stage of plant growth does it attack: seedling, growing or mature plant? **seedling, vegetative, and reproductive stages** – Which plant part is attacked: leaves, roots, stem, fruits, seeds or the entire plant? **leaves, stem, fruits, and tubers** – What kind of damage does it cause: rotting, chlorosis, wilting, spots, etc.? – **Fruits: spots, unusual odour** – **Leaves: spots; abnormal colours; wilting; fungal growth.** – **Vegetative**	off the soil, mulch to reduce water splashes, and remove or deeply dig in old crops after harvest. – Pruning of indeterminate tomato varieties will increase air movement and allow good spray penetration if pesticides are to be used. Irrigating in the heat of the day should allow the crop to dry before nightfall and reduce disease transmission and development. – **Use healthy seeds / planting material:** Use only tomato seeds / transplants and potato tubers that are certified disease free. Growing healthy plants helps to prevent disease in crops. It is recommended to adding compost or well decomposed animal manure, and to sow green manures help to improve soil structure and nutrient content to produce a healthier crop that can tolerate / or resist blight. – **Field sanitation :** Eliminate all early disease inoculum by destroying crop residues such as potato cull piles and tomato debris, prevent growth of volunteer potatoes, and planting tomatoes as far as possible from potatoes. Remove crop residues after harvesting. – **Solarisation:** High temperatures

			organs: leaf necrosis, dry rot. – **Whole plant: seedling blight; leaf necrosis** – When does it attack: in the dry season or the wet season? **cool and moist conditions**	have been used to control Phytophthora in many ways. Steam heat to kill Phytophthora in contaminated soil in greenhouses was used many years ago in the developed / first world countries. Although the industry now uses soil-less media, homeowners can still use this technique. Solar heating in the field by laying out clear polyethylene tarps helps pasteurize the soil. This method has been useful in places with a large proportion of cloudless days. – **Weather forecasts**: Listen to weather forecasts on the possible late blight outbreaks (where such forecasts are broadcasted) or ask for updates from your local agriculturists. The temperature-humidity rule is one of the methods used to forecast the late blight epidemic. Late blight fungus will sporulate (produce spores) when there is a cool and warm temperature that is not less than 10° C, and the relative humidity is over 75% and lasts for 2 consecutive days. – **Tool hygiene:** Clean tools thoroughly before using in a different area of crops to stop the disease spreading. It is advisable to start field

				operations in clean fields and end-up in diseased fields. This would reduce spread of the disease in the farm. – **Tomato seed-treatment:** You can sun-dry tomato seeds for 3 days at about 22°C. After this time the Late blight pathogen is eliminated and you can use the seed for propagation.
9.	Powdery Mildew 	– Carrot – Kale – Spinach – Pawpaw – Okra – Mango – Tomato – Water melon – Cowpea – Eggplant	– What is the cause of the disease: virus, bacteria or fungus? **Fungus** – How is the disease transmitted: by seeds, through the soil, by air or by insects? **Wind** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Seeding, vegetative, and reproductive stages.** – Which plant part is attacked: leaves, roots, stem, fruits, seeds or the entire plant? **Leaves, petioles, stems, and sometimes fruits.** – What kind of	– Avoid late-season applications of nitrogen fertilizer to limit the production of succulent tissue, which is more susceptible to infection. – Avoid overhead watering to help reduce the relative humidity. – Remove and destroy all infected plant parts (leaves, etc.). For infected vegetables and other annuals, remove after harvest as much as possible of the plant and its debris. This decreases the ability of the fungus to survive to next season. **Do not compost infected plant debris.** Temperatures in the compost often are not hot enough to kill the fungus. – Selectively prune overcrowded plant material to help increase air circulation. This helps reduce relative humidity and infection.

			damage does it cause: rotting, chlorosis, wilting, spots, etc.? **Powdery mildews are characterized by spots or patches of white to greyish, talcum-powder-like growth. Tiny, pinhead-sized, spherical fruiting structures that are first white, later yellow-brown and finally black may be present singly or in a group. These are the cleistothecia or over-seasoning bodies of the fungus.** – **The disease is most commonly observed on the upper sides of the leaves. It also affects the lower sides of leaves, young stems, buds, flowers and young fruit. Infected leaves may become distorted, turn yellow with small patches of green, and fall**	

			prematurely. Infected buds may fail to open. – When does it attack: in the dry season or the wet season? **Dry weather when there is high relative humidity**	
10.	Tomato Yellow Leaf Curl Virus Disease (TYLCV) 	– Tomato – Beans	– What is the cause of the disease: virus, bacteria or fungus? **Virus** – How is the disease transmitted: by seeds, through the soil, by air or by insects? **Infected seeds/transplants/**by **whiteflies** – At what stage of plant growth does it attack: seedling, growing or mature plant? **Seedling stage, generative and vegetative growing stage** – Which plant part is attacked: leaves, roots, stem, fruits, seeds or the entire plant? **Leaves, stems and**	• Avoid continuous growing of tomato. Practice crop rotation by planting crops that are not susceptible to whitefly. • Use resistant/ tolerant varieties, e.g. 'Amareto', 'Peto 86', 'Fiona F1', 'Perlina', 'Denise', 'Cheyenne (E448)', 'Rover'. • Mulch the seedbeds. • Protect seedbeds with a white nylon net (40 mesh). • Pull out diseased seedlings. • Protect seedlings from whiteflies • Plant barrier crops like maize around tomato fields. These crops should be sown a month or two before transplanting of tomato. • Mulch tomato fields with sawdust or straw. • Immediately remove infected-looking plants and bury them. • Do not plant cotton near tomato and/or other crops susceptible to

			whole plant. – What kind of damage does it cause: rotting, chlorosis, wilting, spots, etc.? – **Leaves: stunting, bushy growth; reduced size; abnormal forms.** – **Flowers: drop.** – **Stems: abnormal growth.** – **Whole plant: dwarfing.** – When does it attack: in the dry season or the wet season**? High temperatures, and low or no rainfall**	whiteflies or vice versa. • Eradicate weeds. • Plough-under all plant debris after harvest or burn them when possible

PIN, RAIN, DETAILED DESCRIPTION OF THE SELECTED ORGANIC SOLUTIONS

#	Name	Main ingredients/material needed	Step-by-step instructions on how to make/spray the solution from scratch	Pests/diseases/deficiencies this solution is best for	Crops used for of the project	Availability of ingredients/material on the market in NBeG/Aweil
1.	**Soap spray**   Soap has been used as an old remedy to control pests. Salts and fatty acids are found in much soap which acts as selective pesticides.	**Liquid soap** – 0.5 kg of sulphonic acid – 3 table spoons of caustic soda – 20 litres of water – 1 kg of common salt – 1 bottle top of perfume like lemon perfume – Quarter table spoon of colour – Mingling stick – 1kg of SLES/Tibro/ Ungalo	**Making liquid soap** Part A: – 0.5 kgs of sulphonic acid mixed with 10litres of water gradually – 3 table spoons of caustic soda added and stirred – 10 additional litres of water added gradually to mixture in the above 2 steps Part B: – 1 kg of common salt mixed with 1 kg of tibro – The solution in A, added gradually to part B, stirring done each time solution is added. – Add 1 table spoon of urea – Add quarter spoon	– Ants – Aphid – Fruit fly – Leafhoppers – Spider mite – Thrips – Whitefly – Black spot – Canker – Leaf spot – Powdery mildew – Rust – Mealy bug – Scales	– Amaranthus – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	– 0.5 kg of sulphonic acid: **Not Available (imported from Kampala Uganda)** – 3 table spoons of caustic soda**: Not Available (imported from Kampala Uganda** – 20 litres of water: **Not Available (imported from Kampala Uganda** – 1 kg of common salt: **Available** – 1 bottle top of perfume like lemon perfume: **Not Available (imported from Kampala Uganda** – Quarter table spoon of colour: **Not Available (imported from Kampala Uganda**

			of colour – Test pH (optional) – Pack product **Preparation method** **Method 1** – Mix 1 tablespoon of liquid soap with 4 liters of water. **Method 2** – Mix 2 teaspoons mild liquid soap/detergent with 4 liters of water. **Method 3** – Mix 1 tablespoon of washing detergent with 1 cup of cooking oil, to make a stock solution. For a gallon of spray, add 5 to 8 tablespoons of stock solution to a gallon of water. **Method 5** – Mix 2 1/2 tablespoons of liquid soap to a			– 1kg of SLES/Tibro/ Ungalo: **Not Available (imported from Kampala Uganda** – *Note! Alternatively bar soap could be dissolved in water.*

			gallon of water. Stir well. **Application/how to use** – Add soap to water. Use mild soap or potash-based soap/liquid soap. – Start with a lower concentration and make adjustments of the strength after testing on few infested plants. – Always try on few infested plants before going into full scale spraying. Soaps can cause burnt leaves on sensitive plants, like cole crops and certain ornamentals. Several applications in short periods can aggravate drying of leaves. – Apply on the infested plants thoroughly, including the undersides of the leaves. Spray early			

			in the morning or late afternoon.			
2.	Neem Leaf Extract  **Plant parts used** Leaves and seeds **Mode of action** Repellent, insecticidal, antibacterial, antifungal, antifeedant, oviposition and growth inhibiting, and crop and grain protectant.	– 1-2 kg of Neem leaves – Mortar and – Pestle – Used cotton cloth /Sieve – Pot/saucepan – String – Hand sprayer	**Preparation method** – Pound neem leaves gently. – Place in a pot. – Add 2-4 liters of water. – Cover the mouth of the pot securely with the cloth and leave it as such for 3 days. – Strain to get clear extract. **Application /how to use** – Dilute 1 liter of neem leaf extract with 9 liters of water. – Add 100 ml of soap. – Stir well. – Spray on the infested plants.	– Aphids – Grasshoppers – Grubs – Beetles – Leafhoppers – Locusts – Plant hoppers – Scales – Snails – Thrips – Weevils – Whiteflies	– Amaranthus – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	All the materials are available in Aweil, NBeG
3.	Neem seed extract	– 3-5 kg of neem	**Preparation method**	– Aphids	– Amaranth	All the materials are available in Aweil, NBeG

		seeds – Mortar and pestle – Used cotton cloth /sieve – Earthen pot – Soap – Strainer – String – Hand sprayer	– Remove the shells. – Pound seeds gently. – Place in a pot. – Add 10 liters of water. – Cover the mouth of the pot securely with the cloth and leave it as such for 3 days. – Strain to get clear extract. **Application/how to use** – Dilute 1 liter of this extract with 9 liters of water. – Add 100 ml of soap. – Stir well. – Spray on the infested plants.	– Beetles – Bugs – Grasshoppers – Grubs – Flies – Leafhoppers – Locusts – Moths – Nematodes – Plant hoppers – Scales – Snails – Thrips – Weevils – Whiteflies	us – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	
4.	**Neem seed powder extract**	– Matured, dried neem seeds – Mortar and pestle – Basin, Bucket – Muslin pouch – Strainer – Soap (5 ml/10 l of water) – Water – Hand sprayer	**Preparation method** – Remove shells and pulps from seeds in the desired amount. – Then pound seeds gently in such a way that no oil comes out. – Once done, put the desired amount of powder in a Bucket of water. – Stir well for about 10 minutes and steep for at least 6 hours but not	– Bollworm – Aphids – Beetles – Leaf roller – Cutworm – Diamondback moth – Fall armyworm – Grasshopper – Leaf miner – Leaf hopper – Locust – Mexican bean	– Amaranthus – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	All the materials are available in Aweil, NBeG

			more than 16 hrs. – Stir it again for another 10 minutes. – Strain. – Add bottle top of soap. – Stir well. **Application/how to use** – Spray on the infested plants thoroughly. – Spray early in the morning or late afternoon.	beetle – Whiteflies		
5.	**Neem as prophylactic**	– Neem seeds – Neem leaves – Water – Sacks – Mortar – Pestle – Weighing scale/cups – Pot/saucepan – Sieve – Hand sprayer	**Preparation method** – Pound neem leaves or seeds or neem cake. – Put it in a clay pot. – Add twice the volume of water, and then cover securely the opening of the pot. – Let it stand for 3 nights. **Application /how to use Method 1** – To use, divide the filtrate into 4 (or more) and put these separately in opened containers. – Place containers in	– American bollworm – Aphids – Beetle – Cabbage aphid – Cotton leaf roller – Diamondback moth – Cutworm – Giant looper – Grasshopper – Gypsy moth – Hairy caterpillar – Leaf hopper – Leaf miner – Migratory	– Amaranthus – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	All the materials are available in Aweil, NBeG

			strategic areas in the field at night time to repel nocturnal pests. – The smell repels the insects from coming into the field. **Method 2** – Fill in jute sacks with neem cake. – Place the sacks along the water canals. – The dissolved neem cake carried into the field prevents the attack of pests and diseases affecting the roots and tillers. **Notes:** – Neem seed extract should be milky white in color and not brownish. If pounded with the seed coat on, 1 ½ times the amount of seeds are required. – It is very important to add the soap with the oil before adding water. It should be used immediately otherwise oil droplets	locust – Whiteflies		

			will start floating. A knapsack sprayer is better for neem oil spraying because it has the tendency to mix the extract while in the process of spraying. – The 3 extract formulations can also be used for fungal diseases control including those that are soil borne. Neem cake can be used as soil manure- to improve the soil condition and to control various species of nematodes. – About 20 to 30kg of neem seed (an average yield from 2 trees), prepared as neem water can treat one hectare of crop. – Neem water can be stored and will remain effective for 3 to 6 days if it is kept in the dark. **Effect on humans**			

			– None; the proper use of neem has not been associated with any side effects. **Effect on non-target organisms** – Azadirachtin is relatively harmless to butterflies, bees, ladybugs, and wasps since these beneficial organisms feed on nectar and pollen. Azadirachtin must be ingested to be effective so that pests which feed on plants are affected by its content. However, constant spraying of flowering plants with highly concentrated neem products affect bees since they carry contaminated pollen and nectar to the hives – A study was conducted on neem products and their effects on mortality,			

			growth, and reproduction of 7 species of earthworms. Various neem products were incorporated in the upper 10cm soil layer of tomato plots. None of the materials had negative side effects on earthworms. Positive effects on weight and survival were found in soil treated with ground neem leaves and ground seed kernels under greenhouse conditions. – Reproduction was slightly favored over a period of 13 weeks in a neem-enriched substrate in rearing cages			
6.	**All purpose chili spray**	– 1 tsp powdered – red hot pepper – 1 garlic bulb	**Preparation method** – Chop onion and garlic. – Add powdered red	– Leaf eating pests	– Amaranthus – Carrots	All the materials are available in Aweil, NBeG

	 **Plant parts used** Fruit, seeds **Mode of action** Insecticidal, repellent	– 1 small onion – 1 liter of water – 1 tbsp of soap Knife – Strainer – Basin/Bucket – Hand sprayer	pepper. – Mix the above ingredients into the water. – Soak for 1 hour. – Strain. – Add soap. – Stir well. **Application/how to use** – Filling the sprayer. – Spray plants thoroughly. – Repeat spraying when necessary.		– Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	
7.	**Chili spray**	– 4 cups of ripe hot peppers or 5 cups of chili seeds – 30 grams of soap/ 1-2 bottle tops – Cooking pot Strainer – Bottle tops/weighing scale – Hand sprayer – Saucepan	**Preparation method** – In a pot, boil ripe pods or chili seeds in water for 15-20 minutes. – Take the pot from the fire and add 3 liters of water. – Cool and strain. – Add soap. – Stir well. **Application/how to use** – Spray on infested plants.	– Ants – Aphids – Caterpillars – Flies – Mealy bugs	– Amaranthus – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	All the materials are available in Aweil, NBeG
8.	**Chili and neem leaves**	– 10-20 pieces of hot pepper	**Preparation method** – Pound hot pepper and	– Armyworm – Whitefly	– Amaranthus	All the materials are available in Aweil, NBeG

	extract 	– 2-2.5 kg fresh neem leaves – 21 liters of water – 2 tbsp of powdered soap – Mortar and pestle – Basin/Bucket – Hand sprayer	neem leaves. – Add to 1 liter of water. – Soak the mixture overnight. – Strain. **Application /how to use** – Add 20 liters of water and the soap to the filtrate. – Stir well. – Fill-in the sprayer. – Spray on infested plants. – Spray early morning or late afternoon.	– Mosaic virus	– Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	
9.	**Chili and neem seeds extract**	– 12 pieces chopped hot chili – 200 grams fully dried and shelled neem seeds – 4 liters of water – Basin/Bucket – Grinder (mortar and pestle) – Knife – Hand sprayer	**Preparation method** – Grind the neem seeds. – Soak the ground neem seeds in water – Overnight – Add the chopped hot chili. – Strain. **Application method** – Fill in the sprayer – Spray on the infested plants thoroughly. **Notes!** **Effect on humans**	– Aphids – Diamondback moth – Sucking and chewing insects – Whitefly	– Amaranthus – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	All the materials are available in Aweil, NBeG

			– Chili irritates nose, eyes, and skin. **Effect on non-target organisms** – When the pepper extract concentration is so strong, it can burn the leaves and eventually kill the plants			
10.	**Tomato leaf spray (a)** **Plant parts used** Leaves, branches, stems **Mode of action** Insecticidal, repellent	– 1-2 cups of tomato leaves – 2 cups of water – Basin or Bucket – Knife – Strainer – Knife – Mortar and pestle – Hand sprayer	**Preparation method** – Finely chop/pound tomato leaves. – Soak overnight in 2 cups of water. – Strain and add 2 more cups of water. **Application/how to use** – Spray to cover infested plant parts thoroughly	Aphids	– Amaranthus – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	All the materials are available in Aweil, NBeG
11.	**Tomato leaf spray (b)**	– 1kg of tomato leaves – 17 liters of water – Few drops of soap	**Preparation method** – Pound leaves. – Mix with water. – Allow to stand for some time. – Filter	Diamondback moth	– Amaranthus – Carrots – Cowpea – Green Gram	All the materials are available in Aweil, NBeG

		– Mortar and pestle Bucket – Strainer – This quantity is good for 1000 plants. – Hand sprayer	– Stir-in soap. **Application/how to use** – Start application when larvae start to infest plants. **Notes!** **Effect on humans** – None known during the write-up however take extra caution as extract maybe harmful to people with very sensitive skin. **Effect on non-target organisms** – Avoid using spray on other nightshade crops (pepper, eggplant, potato) because of the risk of spreading mosaic virus		– Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	
12.	Onion bulb extract (a)	– 85 grams of chopped onion – 50 ml of mineral oil (kerosene)	**Preparation method** – Add chopped onion to kerosene. – Allow this mixture to stand for 24 hours.	– Whiteflies	– Amaranthus – Carrots – Cowpea – Green Gram	– All the materials are available in Aweil, NBeG

	 **Plant parts used** Bulbs **Mode of action** Insecticidal and repellent	– 10 ml of soap – 450 ml of water – Strainer – Bottle container – Hand sprayer	– Add water and stir-in the soap. – Store in bottle container. **Application/how to use** – Dilute 1 part of the emulsion with 19 parts of water (for example, 50 ml of emulsion to 950 ml of water). – Shake well before spraying. – Spray thoroughly on the infested plant, preferably early in the morning.		– Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	
13.	Onion bulb extract (b)	– 1 kg of bulb onions – 1 liter of water – Cooking pot/saucepan – Bucket – Strainer – Mortar and pestle	**Preparation method** – In a pot, bring 1 liter of water to boil. – Chop the onions, and then place in a covered container. – Pour the boiling water into the container. – Let it stand for 24 hours. **Application /how to use**	– Ants – Scales – Spider mites – Thrips	– Amaranthus – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	All the materials are available in Aweil, NBeG

			– Dilute the 1 liter extract with 10 liters of water. – Spray thoroughly on the infested plant, preferably early in the morning or late afternoon.			
14.	Onion bulb extract (c)	– 50 g of bulb onion – 1 liter distilled water – Bucket/bucket – Strainer – Mortar and pestle	**Preparation method** – Finely chop/grind the onion. – Add to water. – Mix well. – Strain. **Application/how to use** – Spray thoroughly on the infested plant, preferably early in the morning or late afternoon. **Notes!** **Effect on humans** – None known during the write-up, however take extra caution as extract maybe harmful to people	– Alternaria – Anthracnose – Fusarium wilt – Fungal leaf blight	– Amaranthus – Carrots – Cowpea – Green Gram – Okra – Onion – Pepper – Spinach – Tomato	All the materials are available in Aweil, NBeG

			with sensitive skin. **Effect on non-target organisms** – None			
15.	Papaya leaf extract  **Plant parts used** Leaves, seeds, unripe fruit **Mode of action** Repellent, insecticidal, rodenticidal, fungicidal	– 50 grams of finely shredded papaya leaves 8-12 ml of soap – Sieve – Bucket – Water – Mortar and pestle – Knife	**Preparation method** – Soak shredded/ground leaves in 100 ml of water. – Stir vigorously. – Let it stand overnight. Squeeze the extract using the muslin cloth. **Application /how to use** – Dilute the extract with 2-3 liters of water. – Add soap. – Stir well. – Spray thoroughly on infested plant parts.	– Leafy caterpillars – Leaf rust – Mosaic virus – Powdery mildew	– Amaranthus – Carrots – Cowpea – Green Gram – Okra – Onion – Pepper – Spinach – Tomato	All the materials are available in Aweil
16.	Papaya water extract (a)	– 1 kg of papaya leaves – 10 liters of water – Mortar and pestle – Soap – Strainer	**Preparation method** – Pound the leaves. – Add pounded leaves into the water. – Leave to stand for 2 days. – Strain.	– White grub	– Amaranthus – Carrots – Cowpea – Green Gram – Okra – Onion	All the materials are available in Aweil

		– Bucket	**Application/how to use** – Spray on the target pests.		– Pepper – Spinach – Tomato	
17.	Papaya water extract (b)	– 1 kg of papaya leaves – Water – Knife – Soap – Sack – Bucket – Sprayer	**Preparation method** – Finely shred the leaves. – Shake vigorously in a liter of water. – Squeeze through a cloth sack. **Application/how to use** – Dilute the filtrate with 4 liters of water. – Spray on the target pests. **Notes!** **Effect on humans** – None known during the write-up however take extra caution as extract maybe harmful to people with sensitive skin. **Effect on non-target organisms** – None	– Flower thrips – Fruit flies	– Water melon – Mangoes – Tomato	All the materials are available in Aweil

18.	**Ginger rhizome extract**  **Plant parts used** Rhizome **Mode of action** Repellent, insecticidal	– 50 grams of ginger – 12 ml of soap 3 liters of water – Grinder – Strainer – Bucket – 4 kg of ginger are needed to spray 0.4 ha	**Preparation method** – Grind ginger and make into paste. – Mix with water. – Add soap, 1 bottle top. – Stir and strain. **Application/how to use** – Spray on infested plants thoroughly. – If there is no sprayer, make soft brushes out of plant straw or twigs. – Make sure to wet all the infested plant parts.	– American bollworm – Aphids – Plant hoppers – Thrips – Whitefly – Root knot nematode – Brown leaf spot – Anthracnose – Yellow vein mosaic	– Amaranthus – Carrots – Cowpea – Green Gram – Okra – Onion – Pepper – Spinach – Tomato	All the materials are available in Aweil
19.	**Ginger, garlic, and chilli extract**	– 25 grams of ginger – 50 grams of garlic – 25 grams of green chili – 10 ml of kerosene – 12 ml of soap – 3 liters of water – Grinder	**Preparation method** – Soak garlic in kerosene overnight. – Grind and make into a paste. – Add 50 ml water to chili, grind, and make into a paste. – Grind ginger and make into a	– Aphids – Armyworm – Bollworm – Caterpillars – Fruit borer – Leaf miner Shoot borer – Thrips – Whiteflies	– Amaranthus – Carrots – Cowpea – Green Gram – Okra – Onion – Pepper – Spinach – Tomato	All the materials are available in Aweil

		– Bucket – Sprayer – 1 kg garlic, 1kg ginger and chili are needed for 0.4 ha	paste as well. – Mix all ingredients into the water. – Add soap, 1-2 bottle tops. – Filter the extract. – Stir well before spraying. **Application/how to use** – Spray on infested plants thoroughly.			
20.	**Ginger powder extract**	– 20 grams of ginger powder 1 liter of water – Bucket – Sprayer	**Preparation method** – Add powder to water. – Mix well. **Application/how to use** – Spray on infested plants thoroughly. **Notes!** **Effect on humans** – Ginger has no side effects on human beings; however, chili is irritating to the skin and causes pain when it comes	– Powdery mildew – Root rot – Fungal leaf blight	– Amaranthus – Carrots – Cowpea – Green Gram – Okra – Onion – Pepper – Spinach – Tomato	All the materials are available in Aweil

			in contact with eyes. **Effect on non-target organisms** – None			
21.	**Garlic bulb extract (a)**  **Plant parts used** Whole plant, bulbs, leaves, flower **Mode of action** Repellent, insecticidal, nematicidal, fungicidal, antibiotic	85 grams of chopped garlic 50 ml of mineral oil (kerosene or vegetable oil) 10 ml of soap 950 ml of water Strainer Bottle container	**Preparation method** Add garlic to vegetable oil. Allow mixture to stand for 24 hours. Add water and stir in the soap. Store in bottle container. **Application/how to use** Dilute 1 part of the emulsion with 19 parts of water (for example, 50 ml of emulsion to 950 ml of water). Shake well before spraying. Spray thoroughly on the infested plant, preferably early in the morning.	– Bollworm – Armyworm – Cotton stainer – Onion thrips – Root knot nematode – Bacterial diseases – Anthracnose – Downy mildew Rice blast	– Amaranthus – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	All the materials are available in Aweil
22.	**Garlic bulb extract (B)**	– 2 garlic bulbs Few drops of soap 4 cups of water Grinder	**Preparation method** – Grind garlic. – Allow mixture to stand for 24 hours. – Add water and stir in	– Black spots – Blights – Fruit rots – Mildew – Rusts	– Amaranthus – Carrots – Cowpea – Green	All the materials are available in Aweil

		Strainer Bottle container	the soap. – Store in bottle container. – Strain before using **Application/how to use** – Dilute 1 part of the emulsion with 9 parts of water. – Shake well before spraying. – Spray thoroughly on the infested plant, preferably early in the morning.		Gram – Okra – Onion – Pepper – Spinach – Tomato	
23.	**Garlic oil spray**	– 100 grams of garlic – 2 tbsp of mineral oil – 10.5 liters of water – 10 ml of soap Covered	**Preparation method** – Chop garlic finely. Soak garlic in mineral oil for a day. – Add a liter of water and soap. – Blend well by stirring thoroughly. – Strain. **Application/how to use** – Dilute the filtrate with 10 liters of water. Fill the sprayer. Shake sprayer from time to time to avoid oil from floating.	– Imported cabbage worm – Leafhoppers – Squash bugs – Whitefly	– Amaranthus – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	– All the materials are available in Aweil

			Spray on the infested plant thoroughly.			
24.	**Garlic oil emulsion**	– 50 ml of garlic oil 950 ml of water 1 ml of soap	**Preparation method** – Add soap to oil. Blend well by stirring thoroughly. Add water. Stir. **Application/how to use** – To prevent oil from floating, immediately spray extract on infested plants and shake sprayer from time to time. – Spray early in the morning or late afternoon. **Notes!** **Effect on humans** – None known during the write-up, however take extra caution as extract maybe harmful to people with very sensitive skin. **Effect on non-target**	– bollworm Root knot nematode	– Amaranthus – Carrots – Cowpea – Green Gram – Okra – Onion – Pepper – Spinach – Tomato	– All the materials are available in Aweil

			organisms – Garlic spray has a broad-spectrum effect. It is non-selective so it can kill beneficial insects as well. – This is not recommended for aphid control since it kills the natural enemies of aphids. – It should be limited to home and garden applications where natural controls are rarely present.			
25.	Animal manure **(Cow dung extract)** Animal manure has antiseptic and mild anti-fungal properties. Healthy animals and those that are	– Cow dung – Water – Sieve – Sprayer – Sack – Bucket – Sticks	**Preparation method** – Add 1 kg of dried cow dung into 10 liters of water. – Filter the solution. – Add another 5 liters of water to the extract. – Filter it again. **Application/how to use** – Put in water can or sprinkler and apply the solution on	– Bacterial diseases	– Amaranthus – Carrots – Cowpea – Green Gram – Okra – Onion – Pepper – Spinach – Tomato	All the materials are available in Aweil

	feed solely with grasses and or fodders are said to be a good source of manure for disease control.		plants early in the morning. **Notes!** – Apply extract with animal manures at least 60 days prior to harvest. – Wash vegetables and fruits thoroughly before use.			
26.	Animal urine extract Animal urine has antiseptic and mild anti-fungal properties. Healthy animals and those that are feed solely with grasses and or fodders are said to be a good source of urine for disease	– Cow urine – Water – Sprayer – Bucket – Sieve	**Preparation method** – Mix 50 ml of cow's urine and 500 ml of water. **Application/how to use** – Put in water can or sprinkler and apply solution on plants early in the morning. **Notes!** – Apply extract with animal urine at least 60 days prior to harvest.	– Plant diseases caused by virus, fungus, and bacterium	– Amaranthus – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	All the materials are available in Aweil

	control.		– Wash vegetables and fruits thoroughly before use.			
27.	**Compost tea (a)** Matured compost has plenty of beneficial microorganisms that help control fungal diseases on plants. Compost ingredients should include animal manure and tree bark if it is intended for disease control.	– Compost manure – Water – Sacks – Strings – Bucket/drum – Sticks/poles – Grinder	**Preparation method** – Put a gallon (4 liters) of well-matured compost into a 5 gallon (20 liters) container. – Add water until the container is full. – Stir well. – Place in warm place for 3 days to ferment. – Strain. **Application/how to use** – Remove first the diseased plant parts and dispose them properly. – Place the compost tea in watering can or sprinkler. – Spray early morning or late afternoon. – Repeat application after 3-4 days.	– Fungal diseases	– Amaranthus – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	All the materials are available in Aweil

28.	Compost tea (b)	– Compost manure – Water – Sacks – Strings – Bucket/drum – Sticks/poles – Grinder	**Preparation method** – Mix well-matured compost with water at a ratio of 1:6 – Leave the mixture to ferment for 1 week – Filter the solution using a cotton flour sack – Add water to the solution until it has a tea-like color or you can also use it undiluted – Spray on plants every 14 days **Application/how to use** – Remove first the diseased plant parts and dispose them properly. – Place the compost tea in watering can or sprinkler. – Spray early morning or late afternoon. – Repeat application after 3-4 days.	– Powdery mildew – Botrytis gray mold	– Amaranthus – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	All the materials are available in Aweil
29.	Compost tea	– Compost	**Preparation method**	– Late blight	– Amaranth	All the materials are

	(c)	manure – Water – Sacks – Strings – Bucket/drum – Sticks/poles – Grinder	– Mix compost with water at a ratio of 1:5 or 1:8 (1 part of compost by volume to 5-8 parts of water by volume). – Leave the solution to ferment for 3-7 days. – Filter using a cotton flour sack. – Place the compost tea in watering can or sprinkler. – Spray early morning or late afternoon. **Application/how to use** – Remove first the diseased plant parts and dispose them properly. – Place the compost tea in watering can or sprinkler. – Spray early morning or late afternoon. – Repeat application after 3-4 days.	is controlled by compost tea – Botrytis, downy and powdery mildew are controlled by cattle/straw compost extract – Fusarium wilt on tomato is controlled by bark compost tea.	us – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	available in Aweil
30.	**Milk spray**		**Preparation method**	– Red spider	– Amaranth	All the materials are

	Milk diluted in water is used as fungicide by some gardeners because of its active substances and microorganisms that prevent pathogen-causing-disease to multiply. Sour milk and goat's milk are found to encourage the growth of stronger protective coatings on crops.	– Milk – Water – Sprayer – Bucket – Mingling stick	– Mix a liter of milk to 4.5 liters of water (Milk and water ratio is 1 part milk to 9 parts water). **Application/how to use** – Spray at weekly interval as a preventive control measure.	mites – Mildew – Mosaic virus – Blights – and other fungal diseases	us – Carrots – Cowpea – Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	available in Aweil
31.	**Plant ash**	– Ash – Source of heat – Plant residue – Animal dung	**Method 1** – Add a cup of wood ash into 4 liters of	**Pest controlled for method 1:** Cucumber beetle and maggots on cucurbits	– Amaranthus – Carrots – Cowpea	All the materials are available in Aweil

		– Water – Sprayer	water. – Leave to stand for some hours. – Strain to have a clear filtrate. – Make a test on few infested plants first to make adjustment of the strength before going into large scale spraying. **Method 2** – Lay a thick layer of ash around the plants. – This will prevent flies and moths laying their eggs near the stems.	**Pest controlled:** Cutworm and fly maggot	– Green Gram – Kudhra – Okra – Onion – Pepper – Rigila – Spinach – Tomato	