



Growing coloured vegetables – a new trend of vegetable cultivation in Bangladesh

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Coloured vegetables are receiving enough attention very recently as these vegetables contain different health promoting phytochemicals and phytonutrients like carotenoids, anthocyanins, polyphenols, bioflavonoids, ellagic acids, iron, sulfur etc. in their edible parts which have positive health benefits (AICR 2007, Mulabagal *et al.* 2010, Kuswanto and Hardinaningsih 2013, Luo *et al.* 2015, Schereinemachers *et al.* 2015 and Singh and Devi 2015) and along with the green vegetables, different coloured vegetables are being recommended to include in the daily menu (Table.1). Even more 'Eat a Rainbow' is now the slogan in which the importance of daily consumption of coloured vegetables has been emphasized. Also, coloured vegetables have the decorative value and can be grown as ornamental plants which can meet up the aesthetic demand as well. Moreover, pigmentation in plant parts sometimes prevents disease and a pest attack (Singh 1996, Polturak *et al.* 2017) along with the increased tolerance to abiotic stresses as well (Kuswanto and Hardinaningsih 2013). Realizing the importance of coloured vegetables and to popularize intensive vegetable cultivation as well as their regular consumption BRAC Agricultural Research & Development Centre has developed few advance lines of coloured vegetables (red okra, red spinach, white pumpkin, purple hot pepper, reddish purple yard long bean, red stem kang kong, reddish type *Chenopodium*, etc.) and Bangladeshi farmers as well as fancy people have started to cultivate these coloured vegetables in their homestead gardens, market gardens and in the roof top gardens as well.

Red Okra

Considering the importance of health benefits of different coloured vegetables and their implication with the decorative value, red okra variety has been developed in BRAC Agricultural Research & Development Centre by crossing the green fruited virus tolerant early type high yielding variety BARI dherosh-1 with an exotic red okra

accession obtained from Japan (Figs. 1- 4). Both the OP and F₁ red okra hybrids are very productive (yield = 40 - 45 Mt /ha) and can be grown in both Kharif-1 and Kharif-2 season like the traditional green fruited okra. These red okra plants usually produces *anthocyanin* rich red okra pods (Irshad *et al.* 2018) which are bigger in size having low water content thicker pulp having its smooth fruit surface and exhibited tolerance to shoot borer and yellow vein mosaic virus as well. Since these okra varieties have the decorative value and has also *carotene* like the greenish type, plants of red okra varieties can be grown as edging plants in the home gardens as well and through BRAC-AVRDC home garden project an attempt was made to popularize these red okra to the beneficiaries in the project area of Jessore district (Schereinemachers *et al.* 2015).



Fig. 1. Red okra plant with red coloured fruit.



Fig. 2. Red okra flower & fruits.



Fig. 3. Pieces of fresh red okra.



Fig. 4. Compare between dissected red oka & green okra.

A positive response from the beneficiaries have been observed as these showy deep red coloured ladies' finger fruits can also be eaten as raw besides cooking unlike green okra fruits. Moreover, along with *anthocyanin* and *carotene*, it has got other minerals like the green ones. Preliminary investigation also revealed that it has relatively higher amount of sulphur in its fruits as well. Okra being a popular nutritious vegetable, in Bangladesh

these red okra fruits are recommended preferably to eat mixing its fresh fruits with the curries to obtain more nutritional benefits from red okra. It is anticipated that these red okra varieties will not only increase the demand of okra in the market as safe vegetables, it will also increase a sort of enthusiasm among the plant lovers to grow red coloured okra plants in their homestead areas and roof gardens as well.

Table 1. Coloured vegetables & fruit sources of different phytochemicals as well as phytonutrients & their health benefits.

Colour	Phytochemicals & phytonutrients	Sources	Health Benefits
Red	<i>Lycopene, ellagic acid & anthocyanins.</i>	Beets, onions (red), potatoes (red), peppers (red), radishes (red), tomatoes. watermelon etc.	Maintain heart health, memory function, urinary tract health; lower the risk of some types of cancer.
Blue & Purple	Health promoting <i>phytonutrients</i> such as <i>polyphenols & anthocyanins</i> & powerful anti oxidants.	Asparagus (purple), cabbage (purple), carrots (purple), egg plant (purple), peppers (purple), potatoes (purple-fleshed).	Gives extra protection against some types of cancer & urinary tract infections, help boost brain health & vision.
Yellow & Orange	Varying amount of <i>antioxidants</i> such as <i>Vit. C</i> as well as other <i>phytonutrients</i> , including <i>carotenoids</i> and <i>bioflavonoids</i> .	Beets (yellow), carrot, sweet corn, peppers (yellow), potatoes (yellow), pumpkin, squash, sweet potato, tomatoes (yellow) watermelon (yellow).	May help promote heart & vision health and a healthy immune system, they may also help to ward off cancer.
Green	Varying amount of potent phytochemicals such as <i>lutein & Indoles</i> as well as other nutrients.	Beans (green), broccoli, cabbage(Chinese), cabbage(green), celery, cucumber, Chayote squash, greens (leafy), leeks, lettuce, okra, onions (green), peas (green), peppers (green), spinach.	Lower the risk of cancer, improve eye health, and keep the bones and teeth strong.
White/ Tan/ Brown	<i>Allicins</i>	Cauliflower, corn (white), garlic, ginger, kohlrabi, mushrooms, onions, potatoes (white-fleshed), turnips.	Play a role in heart health by helping in maintaining healthy cholesterol levels and may lower the risk of some type of cancer.

(Adopted from AICR 2007, Singh and Devi 2015).

Red spinach

While working on the improvement of traditional green type spinach varieties, an uncommon red coloured spinach variety has been developed at BARDC very recently through selection which is not only exceptional with respect to its colour but also with its nutritional quality (Figs. 5 & 6). Basically it is also an *anthocyanin* rich spinach variety with increased level of *carotene* and *iron*. It can be grown almost throughout the year and its leaves can be harvested 3 to 4 times from a single sowing in the growing season through *cut-and- come-again* method (Biswas 2012). As red spinach has been found to be tolerant to major diseases and has also the decorative value it can be grown in the vegetable and roof garden as well. Its yield and taste are very much similar to traditional type green spinach (yield = 65 – 66 Mt/ha) and seed production is also profitable as sufficient amount of seeds can be obtained from a single plant (almost 60-70 gm of seeds/plant). To enjoy its aesthetic beauty the homestead vegetable growers usually don't uproot the whole plant

when the plant reaches at the edible stage rather they used to harvest the edible size leaves from the lower portion of the stem of each of the plant keeping them fit to facilitate continuous production of leaves. Moreover, since these red spinach plants are relatively tolerant from the attack of major insects & diseases this leafy vegetable has better scope in the safe vegetable market than the traditional greenish type and being less production cost is registered against its seed production, the prospect of red spinach is bright for both as safe vegetable production and quality seed production of spinach.



Fig. 5. Red spinach plant developed at BARDC.



Fig. 6. Traditional type and red spinach.

White pumpkin

Pumpkin is a very popular nutritious fruiting vegetable in Bangladesh and it is grown here with various shapes, sizes and colours although white pumpkin is very rare. Since pumpkin can be grown almost throughout the year and its fruits can be stored up to 4 to 5 months period, cultivating area of sweet gourd is increasing every year and it has become an excellent profitable crop in the 'Char' areas of Bangladesh. With a view to make the pumpkin more popular and also to increase the diversity of pumpkin in the vegetable markets, a decorative type of white pumpkin has been developed at BARDC through selection (Figs.7-10). Its normal looking plants are very much similar to the ordinary type pumpkin and the flower as well as fruiting habit has also been found to be normal. White coloured fruits of this sweet gourd line are more or less flattened round in shape with thicker flesh while the flesh colour is orange yellow. Each fruit is about 4-5 Kg and yield is around 35-40 Mt/ ha. At the early fruit development stage, the young fruits remain light green coloured and gradually the rind colour become whitish green which finally turns into white when the fruits become mature. Its ripened fruits are however light brown coloured (Fig. 10). Its white coloured mature fruits have carotene rich thicker flesh, TSS 6-7° Brix and the fruits are also very tasty.



Fig. 7. White pumpkin Fig. 8. Normal and white pumpkin developed at BARDC.



Fig. 9. Twigs of white pumpkin. Fig. 10. Dissected white pumpkin fruit.

Reddish purple yardlong bean

A high yielding longer red fruited year round open pollinated (OP) yardlong bean variety has been developed through conventional breeding method at BRAC Agricultural Research and Development Centre (Figs. 11 & 12). The plants of this particular variety are very much similar to the traditional green fruited type yardlong bean

plants excepting reddish coloured petiole, longer fleshy red coloured fruits (55-60 cm) and relatively smaller size slender seeds. Its anthocyanin rich tender tasty fruits can be harvested from 45-46 days after sowing of seeds and yield is around 20 -21Mt/ha. This virus free newly developed reddish purple yardlong bean variety exhibited tolerance to leaf miner attack as well. Since its fruits have attractive red colour, these showy red coloured fruits usually attracts the consumers in the vegetable market when these red coloured fruits are mixed with the green fruited bunch. Again when these red coloured fruits are cooked along with the green fruits by mixing them, the cooked item looks better than either of the cooked single variety and invariably better nutrients are ensured to the food lovers. Initially a Chinese whitish type poor yielder long but broad fruited yardlong variety (67- 68cm longer fruits) 'Jijiang' was crossed with a local green fruited variety having moderate yield to increase fruiting habit and change its fruit colour (to make the fruits green as whitish fruits are not liked by the Bangladeshi people) of the Chinese variety. At the end of 6th generation a high yielding line having longer green fruited plants were obtained. This high yielding green type long fruited line was then again crossed with a normal local type reddish fruited variety to incorporate the red fruit colour in the green background of the newly developed high yielding *Green fruited line* and definitely to make its fruits more nutritious i.e. anthocyanin rich. Finally, through generation advancement technique, ultimately the desired high yielding reddish purple yardlong bean line having longer fleshy fruits was obtained which has been found to be superior to the local red fruited yardlong bean variety in terms of production, insect tolerance level and nutrition. Kuswanto and Hardiningsih (2013) also developed purple podded anthocyanin rich yardlong bean lines which exhibited tolerance to pest and disease attack as well as water stress conditions.



Fig. 11. BARDC developed reddish purple fruited bean variety.



Fig. 12. Traditional type green fruited yardlong variety.

Reddish Kang kong

A high yielding advance line of narrow leaf kang kong having reddish stem has been developed at BARDC through hybridization between an introduced vigorous

type Philippino greenish kang kong with a hardy type local semi aquatic narrow leaf kang kong having red stem colour (Figs. 13-14). Usually the Philippino greenish type kang kong forms extra large size leaves during the rainy season which makes them unsuitable for consumption in the monsoon season, when there is always a huge crisis of vegetables in the kitchen market. This is why a new nutrient rich kang kong line has been developed having reddish type of stem which produces relatively narrow marketable size leaves in the rainy season like the normal season. This new red stem kang kong has also been found to be tolerant to *white blister* and *anthracnose* disease which is very common in the Philippino greenish type kang kong. Its yield is almost parallel to greenish type (around 40-45Mt/ha) but the new reddish kang kong line is more tolerant to stress conditions and have the better potentiality to produce more side branches after each cutting.



Fig. 13. Improved type Kang kong with Stem. Fig. 14. Compare between kang kong with green and red reddish Stem.

Purple and black hot pepper

Hot peppers are of different kinds: green, purple, black, white, yellowish white etc. which have different degrees of pungency and different levels of hotness. Purple, white, black upright fruit bearing hot peppers have the ornamental value besides their common use and these hot

pepper plants can easily be grown in the homestead vegetable gardens as well as in the roof top gardens under pot condition besides their commercial cultivation. Since a good number of coloured hot peppers have strong pungency and have moderate to high level of hotness these coloured peppers can be used as spices also. A purple and a black colored upright fruited type hot pepper line have been developed at BARDC recently which can be grown as ornamental plants, side by side its nutritious fruits can be used as spices (Figs. 15 & 16). Purple type hot pepper plants usually produce deep purple coloured leaves at the seedling stage and good looking purple fruits are produced at the fruiting stage. Similarly black fruited hot peppers also produces blackish type young leaves at the seedling stage and usually produce black coloured upright fruits at maturity. The black fruited hot pepper plants exhibited a certain degree of tolerance to high soil moisture and the early monsoon rain usually can not cause very much damage to these pepper plants.



Fig. 15. Purple fruited hot pepper developed at BARDC. Fig. 16. Black hot pepper developed at BARDC.

Therefore, in BARDC a good no. of crops were attempted to make them colourful and these colourful advance lines also exhibited different modified characteristics which has been described in Table.2.

Table.2. Improvements made in coloured vegetables at BARDC through conventional breeding method.

Characters	Modification	Targeted Crop
1. Nutrition	<i>Improved nutrition</i>	Red okra, red spinach, yellow seeded mung bean, Reddish purple yardlong bean, reddish <i>Chenopodium</i> .
2. Yield	<i>Increased yield</i>	Reddish purple yardlong bean, yellow seeded mung bean.
3. Disease tolerance	<i>Tolerance to leaf spot, white blister and anthracnose disease</i>	Red spinach, kang kong having red coloured stem.
4. Insect Infestations	<i>Tolerant to shoot & fruit borer, resistance to leaf miner and tolerant to leaf curl complex.</i>	Red okra, Reddish purple yardlong bean, purple type hot pepper.
5. Plant architecture	<i>Giganticism</i>	Reddish <i>Chenopodium</i>
6. Crop maturity	<i>Shorter crop duration</i>	Yellow seeded mung bean
7. Seasonal sensitivity	<i>Capability of growing in the off season</i>	Red okra & red spinach
8. Adaptability	<i>Tolerant to high soil moisture</i>	Purple & black hot pepper.

Bangladesh is very much suitable for vegetable cultivation due to its vast fertile plain land, enough sunshine throughout the year, distinctly different 6 seasons, good riverain network, favourable edaphic as well as agro climatic conditions and near about 70 - 75 types of vegetable crop species are generally grown in Bangladesh. Also it's diversified agro climatic condition encouraged vegetable growers to grow different types of vegetables round the year in its different geographical locations. In the mean time Bangladesh has already made a significant progress in vegetable cultivation and as vegetable farming ensures swift return to the growers; farmers are now shifting very rapidly towards vegetable production. Again Bangladeshi people have a very good tradition of vegetable consumption although per day/per capita of vegetable consumption is still much less than the WHO-recommended amount of 200 gm/day (Schreinemachers *et al.* 2015). Since coloured vegetables have enormous nutraceutical properties and as these vegetables have also the eye-catching value, it is expected that newly developed coloured vegetables will not only increase the diversity of the vegetable crops; these crops will ensure the expansion of value added vegetable products as well. Side by side consumption of vegetables will be increased substantially by the people who mostly suffer from diseases related to malnutrition (Biswas 2013, Singh and Devi 2015) besides the health-conscious normal vegetarian groups. Again sometimes sales of fresh vegetables are found to be increased when these colourful vegetables are mixed with the traditional types of vegetable varieties. Along with the availability of different phytochemicals and phytonutrients, these diversified colourful crops exhibited some other features which are significant in the agronomical point of view (Table.2). From the preliminary investigation it has been observed that red okra is relatively tolerant to *stem borer*, red spinach has been found to be tolerant to *anthracnose* and other major disease and pest attacks and red stem kang kong has been found to be tolerant *white blister disease* and *anthracnose*. Disease and insect tolerant vegetable varieties are desirable as these varieties usually reduce production cost and at the same time these varieties ensures safe vegetable cultivation and consumption as well. Moreover, since Bangladesh is now emerging as vegetable exporting country these coloured vegetables may be the potential source of functional foods (Irshad *et al.* 2018, Mulabagal *et al.* 2010, Gul *et.al.* 2015) and along with the green vegetables, coloured vegetables may expand the volume of exporting items as well. Since only green vegetables alone cannot meet the nutritional and other requirements, coloured vegetables or

mixing coloured vegetables along with the traditional type of vegetables may be the option to fulfill the growing new demand of vegetable lovers.

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