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Effect of Different Tillage and Residue Management in Productivity of Chickpea under Chickpea-Maize-T. Aman Rice Cropping Pattern in High Barind Soil of Bangladesh

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The field trial was conducted at the farmer's field of FSRD (Farming System Research and Developement) site, Godagari, Rajshahi during *rabi* season 2013-2014 with an objective to observe the effects on yield performance of chickpea under different tillage's and residue mulches for Chickpea-Maize-T. Aman cropping pattern in the High Barind Tract. The experiment was conducted in RCBD with three dispersed replications in the *Rabi* season 2013-14. Three tillage methods *viz.*, (i) T_1 = strip tillage (ii) T_2 = bed planting and (iii) T_3 = conventional tillage in combination with three mulching practice *viz.* (i) M_1 = farmers practices (ii) M_2 = 15% residue straw mulch (iii) M_3=30% residue straw mulch were studied. Interaction effect of tillage and mulching were found significant on soil moisture and also on chickpea yield. Bed planting along with 15% straw mulch produced significantly higher chickpea yield (1.147 t ha^{-1}) and gave higher economic benefit than that with other treatments. The results indicate bed planting coupled with 15% straw mulch might be a good option for better soil moisture conservation and higher economic benefit and yield of chickpea in High Barind Tract of Bangladesh.

Key Word: Tillage options, Crop residue, Chickpea, Maize, T.Aman, High Barind Tract

INTRODUCTION

Rainfed agriculture in the High Barind Tract (HBT) is extremely difficult. The main constraint to crop production is draught due to erratic and low rainfall from October. The total long term mean annual rainfall is 1285 mm at Godagari in the south and 1402 mm at Nithpur in the north (FAO, 1988). The maximum temperature can reach 45^{0}C in May and the minimum can fall to 6^{0}C in January. More than 90% of the rainfall occurs from June to September. Moisture depletion starts from October and in December no residual moisture is normally available for crop emergence, a situation that continues up to April (Idris and Huq, 1987). There is only a short period after harvest of rice during which surface soil moisture conditions are conducive for sowing of Rabi crops. Moisture holding capacity of HBT soil is poor due to critical organic matter contents and low infiltration water (Ali, 2000). In such a situation if soil is opened by plowing of furrowing and exposed to sun drying for long time, soil moisture goes out quickly resulting in poor germination of seed. This is why the region has traditionally remained fallow after rice. Farmers normally grow only one crop of T.Aman rice under rainfed condition in each year. Chickpea yield is probably the most unstable among the pulse grown in Bangladesh due to the extreme sensitivity to micro-environment conditions (Musa *et. al*., 2001). Chickpea is a very suitable dry land winter crop that can grow mainly reliant on residual soil moisture. In the water stressed environment of High Barind Tract (HBT), it can be grown successfully after harvesting of short duration transplanted aman rice (Musa *et. al.* 1999). Barind is a dry land area, so at sowing time if there is a less moisture in the soil resulted

the germination and crop establishment are affected. About 10,000 hectares of land is under chickpea cultivation in the High Barind Tract. The area and yield can be increased by making appropriate adjustment against the adverse climate and soil moisture conditions and appropriate production technology. Moisture holding capacity of HBT soil is poor due to critical organic matter contents and low infiltration of water (Ali, 2000). Farmers normally grow only one crop of T.Aman rice under rainfed condition in each year. They usually cultivate long duration T.Aman rice and dry their crop in the field since 10- 15 days. By this time residual soil moisture goes up and farmers could not able to establish different rainfed Rabi crops. Tillage operations and provision of plant nutrients are one of the necessary strategies for increasing yield of rainfed chickpea cultivation (Ali Dalvand and Mohammad Mehranzadeh, 2013).Tillage practice plays a vital role in conservation of residual soil moisture in rainfed cultivation. Yields of greengram were significantly higher in maize–chickpea and maize–mustard systems, more so with residue addition (Meena *et. Al*., 2015). However, information on sowing time and tillage options for chickpea cultivation using residual soil moisture after harvest of T.Aman rice in High Barind Tract is inadequate. Therefore, the present study was carried out to evaluate the effect of residue management and tillage options on chickpea using residual soil moisture after harvest of T.Aman rice.

MATERIALS AND METHODS

The field trial was conducted at the farmer's field of FSRD site, Kadamshahar, Godagari, Rajshahi during *Rabi* season 2013-2014. The experiment was laid out in a randomized complete block design with three dispersed replications. . Three tillage methods *viz.*, (i) T_1= strip tillage (ii) T_2=bed planting and (iii) T_3= conventional tillage in combination with three mulching practice *viz.* (i) M_1=farmers practices (ii) M_2=15% residue straw mulch (iii) M_3=30% residue straw mulch were studied. The trial was laid out in RCBD with three compact replications. The dimensions of individual plots were 5 m x 4 m. Tillage treatments were placed in the main plots and mulch treatments in the sub-plots. Chickpea variety BARI Chola-9 was used as a test crop in the study. The land was fertilized with 18-12-20 N-P-K kg ha^{-1} (BARC, 2005) in the form of urea, triple super phosphate and muriate of potash, respectively. All fertilizers were applied as basal according to individual plot and mixed with soil at the time of final land preparation. Seeds of chickpea were sown in line maintaining a spacing of 30 cm with continuous sowing at 30 November 2013. Intercultural operations viz. weeding and pesticide spray were done in order to support normal plant growth. Soil moisture regimes of the experimental plots were recorded at a depth of 0-15cm at 15-days intervals. Data on yield component was collected from randomly selected 10 plants from each unit plot. For yield data, whole plot was harvested at maturity and the recorded data was converted to kg per hectare. The crops were harvested on 06 April, 2014. The data were analyzed statistically and the mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

No of plant per m^2

As is shown in (Table 1), the effects of the two factors of tillage and residue management on plant per m^2 were significant at the five percent probability level. Comparison of the means of the treatments indicated that there were very significant differences between the treatments combinations and that the maximum plant per m^2 (32) belonged to the treatment T_3M_3. On the other hand, lowest was found on treatment combination T_1M_1.

Number of Pods per Plant

The results of analysis of the variance of the effects of the two factors of tillage and mulches application and the mutual effects of these two factors, on the number of pods per plant, shown in (Table 1), indicate that they were significant at the five percent probability level. Comparison of the means of the tillage and mulch combination treatments indicated that there were very significant differences between the various types of tillage, and that the maximum number of seeds per pod belonged to the treatment T_3M_3.

Seed and Stover Yield

Results of analysis of the variance in (Table 1) show that the effects of tillage and of mulch application on seed yield were significant at the

five percent probability level. Significantly the maximum grain yield (1.43 t ha^{-1}) was recorded from T_3M_3 followed by T_3M_2 (1.147 t ha^{-1}) and the minimum grain yield (0.87 t ha^{-1}) was obtained from T_1M_2. Maximum straw yield (1.873 t ha^{-1}) was recorded from T_3M_3 followed by T_2M_1 (1.813 t ha^{-1}) and the minimum (1.583 t ha^{-1}) from T_1M_3. Improvement in vegetative growth, and the increase in seed yield, should be attributed to the provision of plant nutrients, especially nitrogen, resulting from the burning of crop plant residues. Moreover , they stated that , in any case , the reduction in soil density in the treatments of burning crop plant residue + plowing with a reversible plow + two disking operations possibly has a considerable share in the increase in vegetative growth and in the accumulation of dry matter per unit area. They also added that nitrogen causes an increase in the leaf area index and, hence, increases the degree of sunlight absorption (Ercoli, 2008).

CONCLUSION

Inclusion of chickpea in a maize–T.Aman system could be a viable option for obtaining higher crop productivity, improving soil fertility, and increasing energy efficiency. The impact of tillage in this study is short-term, and the systems are yet to reach equilibrium. Although results may vary in the long-run, the short-term changes provide an indication of the direction of changes, and a useful notion on the advantages and limitations in adopting specific agronomic management practices. The performance of conventional tillage and 30% straw mulch combination was best among other combination recommended for chickpea production in High Barind Tract.

Table 1: Effect of tillage practice and mulches on the yield and yield contributing characters of chickpea under Chickpea-Maize-T.Aman cropping pattern

Treatment	Plant height (cm)	No. of plant m^{-2}	No. of pods $plant^{-1}$	No. of seeds pod^{-1}	1000- seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1 M_1	32.51 d	25 e	29.25cd	1.40b	17.78de	0.897c	1.697abc
T_1 M_2	34.53 cd	28.33 cde	28.29 d	1.40 b	17.860 cd	0.870 c	1.640 bc
T_1 M_3	34.70 cd	27.33 de	31.86 bcd	1.40 b	17.900 cd	0.997 b	1.583 c
T_2 M_1	38.10 bc	28.66 bcd	35.38 abcd	1.60 ab	18.027 bcd	1.06 ab	1.813 ab
T_2M_2	34.66 a	28.66 bcd	36.24 abc	1.66 a	18.230 abcd	1.093 ab	1.717 abc
T_2 M_3	45.63 a	29.33 abcd	36.23 abc	1.40 b	17.840 cd	1.070 ab	1.730 abc
T_3M_1	40.03 b	32.66 a	37.24 ab	1.60 ab	18.380 abc	1.133 a	1.840 a
T_3M_2	37.00 bc	31.00 abc	38.39 ab	1.60 ab	18.573 ab	1.147 a	1.800 ab
T_3M_3	37.26 bc	32.00 ab	40.73 a	1.73 a	18.633 a	1.43 a	1.873 a
CV (%)	5.30	1.06	11.51	8.42	1.63	5.16	5.33

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Development and Evaluation of Native Plant Growth Promoting Rhizomicrobial Consortia on Growth Parameters of Sweet Corn (*Zea mays convar. saccharata var. rugosa*)

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An attempt was made to isolate, screen, and evaluate the different Plant Growth Promoting Rhizomicrobial consortia on growth parameters of sweet corn (*Zea mays convar. saccharata var. rugosa*)". In the course of the study, as many as five *Acetobacter*, four phosphate solubilizing bacteria and four potassium solubilizing bacterial isolates were isolated from the rhizosphere soils of Malnad regions. Further all the isolates were screened under*in vitro* condition. Out of five *Acetobacter* isolates, Aceto-5 fixed a maximum of 4.8mg of nitrogen/g of carbon source. Hence Aceto-5 was selected for further studies. Similarly, Out of four PSB isolates the maximum inorganic phosphorus was released by PSB-3, hence it was selected and with reference to potassium solubilization, the KSB 3 was efficient. Hence all the efficient isolates *viz.,* Aceto-5, PSB-3 and KSB-3 were selected. Further the effective native Plant Growth Promoting Rhizomicrobial consortia carrier based formulations was developed and evaluated on growth parameters of sweet corn. With respect to germination percentage, number of leaves, chlorophyll content and plant height, the triple inoculation treatment resulted better than other treatment imposed indicating the combined inoculation of PGPR is having an impact on sweet corn. Finally, the treatment where *Acetobacter*-5, phosphate solubilizing bacteria-3 and potassium solubilizing bacteria-3showed maximum accumulation of NPK content in leaves after 90 days and the same treatment also showed increased residual nitrogen, phosphorus and potassium level in the soil.

Keywords: Rhizomicrobial Consortia, corn

INTRODUCTION

As we enter the third millennium with more than six billion people, we are confronted with a herculean task of providing environmental and food security to the expanding population particularly in the developing countries. This calls for the reorientation of strategies to minimize the use of external inputs in agriculture and depend more on eco-friendly approaches to sustain food production without causing disruption to the fragile agro-ecosystem. Nowadays the biological means of production is gaining lot of importance. Among the biological means. Microorganisms being an integral component of soil ecosystem which play a prestigious role by making the soil truly living. These organisms have the direct impact on growth and yield of plants by many mechanisms, such as nutrient availability, diseases and pest suppression and also production of plant growth promoting hormones *viz.,*Ethylene, Gibberellins, IAA, Auxin*etc.* In this contest there is a growing interest to concentrate much on plant growth promoting rhizomicroorganisms in agriculture.

On the other hand, soil is dynamic systems with multiple interactions between organic and inorganic soil components and these interactions in soil are important for the

microorganisms and availability of mineral nutrients. Numerous microorganisms are especially those associated with roots have the ability to increase the plant growth by solubilizing or releasing the unavailable mineral nutrients and also increase soil fertility (Ledin *et al*., 1996). In ecosystem with low inputs and without any fertilization or soil amendments by humans, the nutrients available to plants come from atmospheric inputs and weathering of soil minerals (Christophe *et al.*, 2006)

The microorganisms being soil engineers play a diverse role in organic sweet corn production by converting unavailable nutrients to available form and also used in suppression of many of the pests and diseases. Among the different microorganisms used in sweet corn cultivation, the nitrogen fixing microorganisms like *Acetobacter*, phosphorous solubilizing bacteria and potassium solubilizing bacteria are used extensively in single,double and triple inoculant formulation however the native efficient isolates are not concentrated much in sweet corn production.

Madhaiyan *et al., (*2004) have reported the occurrence of *Gluconoacetobacter diazotrophicus* in tropical and subtropical plants of Western Ghats of India. Further they isolated *Gluconoacetobacter diazotrophicus* from different crops like maize, beetroot and carrot capable of nitrogen fixation and phosphorous solubilization.

Sarita and Bhattacharya (2000) isolated *Acetobacter diazotrophicus* capable of solubilizing potassium from the different soil samples collectedfrom different sugary crops like sweet sorghum, maize, sugarcane and beetroot.

Samina Mehnaz *et al.,* (2006) studied the inoculation effects of *Pseudomonas putida, Gluconoacetobacterazotocaptans*, and *Azospirillum lipoferum* on corn plant growth under greenhouse conditions.

Conceptual design is important in developing new technologies and also utilization of different beneficial plant growth promoting rhizomicroorganisms for sustainable vegetable production. The basis of conceptual design is simply to first convince a model and then to devise a strategy and method for achieving the reality. However, it is necessary to carefully co-ordinate the minerals, the environment and the technologies constituting the methods. Moreover one should adapt a philosophical attitude in applying microbial technology to corn production and also for soil health management. Based on the past work done by different researchers and in a view of greater need for developing Plant Growth Promoting Rhizomicroorganisms (PGPR) consortia for healthy sweet corn production the present investigation was undertaken to isolate, screen, and evaluate the different plant growth promoting rhizomicrobial consortia on growth parameters of sweet corn.

MATERIALS AND METHODS

Collections of soil samples

A total of 20 different soil samples were collected from different sugary crop rhizosphere like beetroot, carrot, sorghum and maize for isolation of different plant growth promoting rhizomicroorganisms.

Isolation of Plant Growth Promoting Rhizomicroorganisms (PGPRs)

Fresh soil samples of different sugary crops collected were serially diluted and plated on the glucose yeast extract peptone media supplemented with Bromothymol blue (Kadere *et al.,* 2008) and for the phosphate solubilizing microorganisms were isolated from the pooled soil using Pikovaskay's agar media (Pikovaskay, 1948) and the same soil samples were used to isolate potassium solubilizing microorganisms using Alexandrove's media. (Hu *et al.,* 2006)

Identification and characterization of PGPR isolates

The nitrogen fixing *Acetobacter*, phosphorus and potassium solubilizing bacteria were identified and characterized based on various morphological and biochemical characteristics. Bacterial strains isolated were examined for colony morphology, pigmentation, cell shape and Gram's staining as per the standard procedure given by Anon (1957) and Barthalomew and Mittewer (1950).

In vitro screening of plant growth promoting rhizomicroorganisms for the plant growth promoting activity

***In vitro* screening of *Acetobacte*r isolates for their nitrogen fixing ability:** All the *Acetobacter* isolates were inoculated to the nitrogen free GYP medium and incubated for 5 days and after 5 days of incubation, 1 ml broth cultures of each

tube was centrifuged at 8000 rpm for 5 min. The supernatant was discarded and the pellet was re-suspended in sterile distilled water. The washing was repeated thrice to remove the traces of the medium and the pellet was suspended in one ml sterile distilled water. Five micro liters each of the suspension was spotted on N free medium. The plates were incubated at 28 ± 2 °C and observations on growth were recorded at 24 hr interval for 5 days and good grown colonies were subjected for quantitative estimation of nitrogen.

Quantitative estimation of nitrogen by *Acetobacter*: To 250 ml conical flasks, 100 ml of the N free GYP medium was dispensed for all flasks and autoclaved. One ml of culture was inoculated to each flask. The flasks were incubated at 37^0 C for seven days. After seven days of incubation the culture was homogenized and 10 ml was digested with 5 ml of concentrated H_2SO_4 along with 0.2 g digestion catalyst mixture K_2SO_4 : $CuSO_4$: Selenium (100:10:1). After cooling, volume was made up to 100 ml with distilled water. Later, 10 ml of aliquot was transferred to microkjeldhal distillation unit, for which 20 ml of 40 per cent NaOH was added and distilled. Ammonia evolved was trapped in 4 per cent boric acid mixed indicator (Bromocresal green 0.066 g and methyl red 0.033 g in 100 ml methanol) till the solution turned from pink to green and then titrated against 0.05 N H_2SO_4till the green colour is turned to pink and total nitrogen content of the culture was determined and results were expressed as mg of N fixed per g of glucose.

$$\text{Percent N} = \frac{\text{Titre value} \times 0.014 \times \text{N of } H_2SO_4 \times \text{vol. made}}{\text{Volume of sample used}} \times 100$$

***In vitro* screening of phosphorus solubilizing bacteria**

Agar plate method: All the phosphorus solubilizing bacterial isolates were spotted on Sperber's media for analyzing the phosphate solubilizing potentiality of each isolates. Based on the zone of solubilization of phosphorus on the media the phosphate solubilizing potentiality was interpreted (Gaur, 1990).

Chemical method: Isolates of the phosphate solubilizing bacteria (10 ml of the overnight culture were inoculated to 100 ml of Pikovskaya's broth in 250 ml flask with equal number of uninoculated controls. The flasks were incubated on a mechanical shaker at 28^0 C for 10 days. The amount of pi released in the broth in flasks was estimated at 10 days after inoculation. The broth cultures of bacteria were centrifuged at 9000 rpm for 20 minutes in a centrifuge to separate the supernatant from the cell growth and insoluble phosphate. The available pi content in the supernatant/filtrate was estimated by phosphomolybdic blue colour method (Jackson, 1973).

In vitro screening of potassium solubilizing bacteria for K released from insoluble K bearing mineral

Agar plate method: All the potassium solubilizing bacterial isolates were spotted on Alexandrov's media containing mica for analyzing the potassium solubilizing potentiality of each isolates. Based on the zone of solubilization of potassium (mica) on the media the potassium solubilizing potentiality of the potassium solubilizing bacteria was interpreted.

Chemical method: The isolates showing zone of solubilization on Alexandrov's agar were further examined for their ability to release K from broth media (supplemented with 1 per cent muscovite mica). One ml of overnight culture of each isolate was inoculated to 25 ml of Alexandrov's broth (Hu *et al.*, 2006) in replicates. All the inoculated flasks were incubated for two weeks at 28±2°C. The amount of K released in the broth was estimated at 7, 15 and 20 days of incubation from triplicate flasks at each stage in comparison with a set of uninoculated controls. The broth cultures were centrifuged at 10,000 rpm for 10 minutes in the remi microcentrifuge to separate the supernatant from the cell growth and insoluble potassium. The available K content in the supernatant was determined by flame photometry (Sugumaran and Janarthanam, 2007).

Development and Evaluation of Pgpr Microbial Consortia on Growth and Yield of Sweet Corn

Compatibility Analysis of Efficient PGPR isolates: The efficient N fixing, P and K Solubilizing isolates were purified and streaked on the Nutrient agar medium for testing their

compatibility. Based on the compatibility results the PGPR carrier (talc based) formulation was prepared for green house evaluation.

Evaluation of PGPR Consortia On Growth Of Sweet Corn

Preparation of carrier based formulations of PGPR consortia: The efficient PGPR isolates were mixed with talc to produce the carrier based formulation as given by Sireesha (2000) separately and based on the amount of Nitrogen fixed by *Acetobacter*, inorganic phosphorous and potassium released by the PSB and KSB isolates and also based on the compatibility analysis the developed PGPR microbial consortia, were evaluated for its influence on plant growth under greenhouse condition using sweet corn as test crop and the inoculation were made as single, dual and triple combination to the sweet corn pots (Plate 1).

Treatment details of the pot experiment

T_1 = Control (RDF)
T_2 = RDF + *Acetobacter (Aceto - 5)*
T_3 = RDF + PSB - 3
T_4 =RDF + KSB - 3
T_5 =RDF + *Acetobacter (Aceto - 5)* + PSB - 3
T_6 =RDF + PSB – 3 + KSB - 3
T_7 = RDF+ *Acetobacter (Aceto - 5)* + KSB - 3
T_8 =RDF + *Acetobacter (Aceto - 5)* + *PSB – 3* + KSB – 3

RESULTS AND DISCUSSION

Isolation of plant growth promoting microorganisms

As many as 5 *Acetobacte*r were obtained from the soil samples collected and for further studies they were named as Aceto-1, Aceto-2. Aceto-3, Aceto-4 and Aceto-5. Based on the zone of solubilization of phosphorus on Sperber's media, four phosphate solubilizing bacterial isolates were obtained from the rhizosphere soil samples and all the PSB isolates named as PSB-1, PSB-2, PSB-3, and PSB-4. Unlike phosphorus solubilizing bacterial bacteria, the potassium solubilizing bacteria were also isolated using the specific Alexandrove's media. Four potassium solubilizing microbial isolates (KSB-1, KSB-2, KSB-3, and KSB-4) were isolated based on the ability of the KSB isolates to solubilize the mica in Alexandrove's media (plate -2). The results are in agreement with the findings of Gaur *et al*., (1976) who isolated three strains of *Bacillus* species from the soil samples of mussoriee rock phosphate capable of solubilizing tri-calcium phosphate.

In support of Gaur *et al*., (1976) Cavalcanteand Dobreiner J. (1998) isolated *Gluconoacetobacter diazotrophicus* from the rhizosphere of sugar cane. Similarly Hu *et al*., (2006) also isolated potassium solubilizing microorganism from the different soils using Alexandrove's media.

***In vitro* screening of plant growth promoting microorganisms for their plant growth promotional activity**

Statistically highest nitrogen fixing ability was observed in Aceto - 5 isolate (4.8mg of nitrogen/g of carbon source) followed by Aceto-4 (4.10mg of nitrogen/g of carbon source) respectively. However, the Aceto-1, Aceto-2 and Aceto -3 also showed the nitrogen fixing ability but comparatively low to with Aceto-5 (Table 1). Similar findings were also reported by Fuentes *et al*., (1993) who isolated and screened 18 strains of *Acetobacter diazotrophicus* isolates from thirteen cane rhizosphere cultivars of Mexico.

Table 1. Nitrogen fixing potential of *Acetobacter* under *in vitro* condition

Sl. No.	*Acetobacter* isolates	Nitrogen (mg/g of carbon source)
1	Control	$0.50^{(e)}$
2	Aceto - 01	$3.93^{(c)}$
3	Aceto - 02	$3.97^{(c)}$
4	Aceto - 03	$3.40^{(d)}$
5	Aceto - 04	$4.10^{(b)}$
6	Aceto - 05	$4.80^{(a)}$
SEM ±		0.62
CD @ 1%		1.79

Note: Means followed by the same letters do not differ significantly.

The results obtained on the zone of solubilization of phosphorus on Sperber's media and percentage of inorganic phosphate released by the phosphate solubilizing microbial isolates is furnished in Table 2. The highest zone of solubilization (1.5 cm) and maximum inorganic phosphate released was observed in PSB - 3 Isolate at 10^{th} day after the inoculation. Similarly, with reference to potassium solubilization by potassium solubilizing isolates, the isolate

number KSB-3 is more efficient in releasing available potassium and maximum zone of solubilization of mica in Alexandrove's agar at the 10th day after inoculation (44.49mg/ml and 1.45cm, respectively) (Table 3).

The results are in agreement with the findings of Gaind and Gaur (1981), who isolated and screened *Bacillus megaterium, Bacillus brevis, Bacillussubtilis* from the rhizosphere of Oat and Arhar. Similarly, Murulikannan (1986) isolated and screened silicate solubilizing bacteria from rice rhizospheres. Similarly Kannan and Raj (1998) also screened 17 *Bacillus* species for their potassium solubilizing ability.

Table 2. Percent inorganic phosphorus released by phosphorous solubilizing bacterial isolates under *in vitro* condition

Sl. No	PSB Isolates	Zone of solubilization on Sperber's media	Inorganic phosphorus released(%) at 10th day after inoculation
1	Control	0.00	3.10 e
2	PSB-1	0.95	4.10 d
3	PSB-2	1.00	5.30 c
4	PSB-3	1.50	7.80 a
5	PSB-4	1.10	6.50 b
		SEM ±	0.16
		CD @ 1%	0.46

Note: Means followed by the same letters do not differ significantly

Table 3. Amount of Potassium released (mg/ml) by potassium solubilizing bacterial isolates under *in vitro* condition

Sl. No	KSB isolates	Zone of solubilization on Alexandrove's media	Amount of potassium released (mg/ml)at 10th day after inoculation
1	Control	0.00	0.07 e
2	KSB-1	0.60	8.12 d
3	KSB-2	0.90	23.00 c
4	KSB-3	1.45	44.49 a
5	KSB-4	1.35	37.07 b
		SEM ±	0.18
		CD @ 1%	0.67

Note: Means followed by the same letters do not differ significantly

Identification of efficient plant growth promoting rhizomicroorganisms

Since, Aceto-5, PSB-3 and KSB-3 were found to be the efficient plant growth promoting rhizomicrobial isolates.All the three isolates were selected for further studies and was tentatively identified and confirmed as *Acetobacter*, phosphate solubilizing *Bacillussp.*and potassium solubilizing *Bacillussp.*based on morphological and biochemical tests (Table 4).

Table 4.Morphological and biochemical characterization of efficient microbial isolates

Sl. No.	Isolates	Morphological tests		Biochemical tests															
				ES	CS	CT	H_2S	IP	NR	MR	VP	CH	CU	UA	SH	GL	A	G	PG
		Colony morphology	Gram's reaction and cell shape																
1	Aceto-5	Yellowish color Smooth colony	Gram negative Small rods	-	+	+	-	+	+	-	-	+	+	+	+	-	+	+	*Acetobacter*
2	PSB-3	Creamy white Smooth colony	Gram positive Rods	+	+	+	+	+	-	-	+	-	+	-	+	+	-	+	*Bacillus*
3	KSB-3	Creamy white Smooth colony	Gram positive Rods	+	+	+	+	+	-	-	+	-	+	-	+	+	-	+	*Bacillus*

ES - Endospore Staining; CH – Casein Hydrolysis; CS – Crystal Staining; CU – Citrate utilization; CT – Catalase Test; UA – Urease Activity; H_2S – Hydrogen Sulphide production; SH – Starch Hydrolysis; IP – Indole Production; GL – Gelatin Liquefaction; NR – Nitrate Reduction; A – Acid Production; MR – Methyl Red; G – Gas Production; VP – VogerProskauer's; PG – Probable Genera

Development and evaluation of efficient Plant Growth Promoting Rhizomicrobialconsortia on growth parameters of sweet corn

Compatibility evaluation

It was observed that all these efficient Plant Growth Promoting Rhizomicrobial isolates are compatible to each other when they are grown in common media. Based on the compatibility evaluation, the consortial formulation was developed and further used for pot experiment studies.

Influence of efficient Plant Growth Promoting Rhizomicrobial consortia on growth parameters of sweet corn

Germination percentage and Number of Leaves: An evaluation of efficient *Acetobacter,* Phosphorus solubilizing bacteria and potassium solubilizing isolates in single, double and triple inoculation combinations were evaluated to know their effect on germination percentage of sweet corn Statistically, highest germination percentage was observed in the treatment 7 (RDF + *Acetobacter* (Aceto-5) + *Bacillus* PSB 3) and treatment 8 (RDF +*Acetobacter* (Aceto 5) + *Bacillus*PSB-3 + *Bacillus* KSB-3) whereas least germination percentage of 95% was observed in treatment number 1 and 2 (Control and RDF + *Acetobacter* (Aceto-5).

On the other hand, with reference to number of leaves the maximum number of leaves were observed in treatment number 8 (11,16 and 22 at 30,60 and 90 days after sowing) followed by treatment number 7 that is 9,12 and 19 at 30,60 and 90 days indicating the effect of Plant Growth Promoting Rhizomicrobial consortia on number of leaves. The statistically less number of leaves were observed in treatment number 1 and 3(control and RDF + *Bacillus* PSB-3) (Table 5).

Table 5. Effect of PGPR consortia on germination percentage and number of leaves of sweet corn

Sl. No.	Treatments	Germination (%)	Number of leaves		
			30 days	60 days	90 days
1	Control	95	8.50 de	13.00 bc	17 d
2	RDF + *Acetobacter* (Aceto-5)	95	8.00 d	14.00 b	19 b
3	RDF + *Bacillus* (PSB-3)	96	7.50 e	11.00 e	15 f
4	RDF + *Bacillus* (KSB-3)	96	9.00 c	14.00 b	17 d
5	RDF + *Acetobacter* (Aceto-5) + *Bacillus* (PSB-3)	98	10.00 b	13.00 bc	16 e
6	RDF + *Bacillus* (KSB-3) + *Bacillus* (PSB-3)	95	8.50 d	12.00 d	18 e
7	RDF + *Acetobacter* (Aceto-5) + *Bacillus* (KSB-3)	100	9.0 c	12.00 d	19 b
8	RDF + *Acetobacter* (Aceto-5) + *Bacillus* (KSB-3) + *Bacillus* (PSB-3)	100	11.0 a	16.00 a	22 a
	SEM ±	0.48	2.607	6.186	6.139
	CD @ 1%	1.79	0.907	1.592	1.586

Note: Absolute Control = Only Soil without compost or fertilizer treatment; RDF = Recommended Dose of Fertilizer; Means followed by the same letters do not differ significantly

Similar findings were also reported by Sugumaran and Janarthanam, (2007) who studied the effect of potassium and phosphorus solubilizing bacteria on germination of sweet corn seeds. Similarly, Leyval and Berthelin (1991) also conducted the green house experiment using potassium solubilizing microorganism and ectomycorrhizal fungus to know the effect of the dual inoculation of KSB and *Mycorrhiza* growth on leaf number of pine.

Total chlorophyll content and Plant height: Statistically the highest chlorophyll content of 2.54 mg/g of tissue was observed in triple inoculation of Aceto-5, KSB-3 and PSB-3 followed by inoculation of Aceto-5 and KSB-3. Further, statistically on par results were obtained in treatment number 6 and 2. The least chlorophyll content of sweet corn leaves were observed in control treatment.However**,** It was observed from Table 6 that plant height of 45cm was in treatment number 8 followed by 5 and 3at 30 days. On the other hand, at 60 days the same trend was continued, however, at 90 days the maximum plant height was observed in triple inoculation of *Acetobacter*-5, PSB-3 and KSB-3. The perusal of Table 6 clearly indicates increase in the plant height due to the treatment of

microbial consortia. The treatment number 8 (RDF + *Acetobacter*Aceto-5+ *Bacillus* KSB-3) showed increased plant height from 45-80 cm up to 90days. The results are in line with the findings of Han *et al., (2006)* who reported the effect of co-inoculation of phosphorus and potassium solubilizing bacteria on growth of pepper and cucumber along with the Recommended Dose of Fertilizer.

Influences of PGPR inoculants on NPK content of plant and soil

With reference to nitrogen and phosphorus level in plants, all the treatments showed good accumulation of nitrogen. However, statistically significant high nitrogen accumulation of 297.33 mg/plant was observed in the treatment 8, where the triple inoculation of all the efficient PGPR isolates were used along with the recommended dosage of fertilizers. Similarly, With reference to phosphorus the result showed increase in phosphorus content, where the consortial application of Aceto–5, PSB–3 and KSB–3 was used (285 mg/plant). Same trend of results reveled with respect to potassium, where the highest potassium content accumulation was recorded in consortial application of Aceto–5, PSB–3 and KSB–3(259 mg/plant).Similar results were obtained in the findings of Ishque *et al*., (2009) who evaluated six different levels of nitrogen along with *Azospirillum* on growth, number of leaves, plant height and also nutrient status of the lettuce plant after harvest.

However, when the soil nutrient status was analyzed chemically, similar results were obtained where nitrogen, phosphorus and potassium content levels recorded high in the treatment where triple inoculation of PGPR was done along with the RDF. However, in the absolute control, the NPK level was very less with reference to N, P and K content. Maximum soil NPK was observed in the treatment number 8 and the least NPK was observed in treatment number 1(Absolute control) (Table-7). Similar findings were reported by Park *et al*., (2003) which can prove the bacterial inoculation could improve phosphorus and potassium availability in the soils by producing organic and other chemicals by stimulating growth and mineral uptake of plants.

Table 6. Influence of PGPR Consortia on Total Chlorophyll Content and Plant height of Sweet Corn

Sl. No.	Treatments	Chlorophyll (mg/g of tissue)	Plant height or Shoot Length(cm)		
			30 days	60 days	90 days
1	Control	0.87 h	40.60	50.00	75.00
2	RDF + *Acetobacter* (Aceto-5)	1.96 cd	42.00	55.00	74.00
3	RDF + *Bacillus* (PSB-3)	1.16 g	44.00	56.00	76.00
4	RDF + *Bacillus* (KSB-3)	1.81 e	38.00	51.00	84.00
5	RDF + *Acetobacter* (Aceto-5) + *Bacillus* (PSB-3)	2.00 b	44.00	54.00	83.00
6	RDF + *Bacillus* (KSB-3) + *Bacillus* (PSB-3)	1.98 c	41.00	52.00	81.00
7	RDF + *Acetobacter* (Aceto-5) + *Bacillus* (KSB-3)	1.70 f	39.00	53.00	80.00
8	RDF + *Acetobacter* (Aceto-5) + *Bacillus* (KSB-3) + *Bacillus* (PSB-3)	2.54 a	45.00	61.00	88.00
	SEM ±	0.08	0.03	0.21	0.56
	CD @ 1%	0.01	0.10	1.57	1.72

Note: Absolute Control = Only Soil without compost or fertilizer treatment; RDF = Recommended Dose of Fertilizer; Means followed by the same letters do not differ significantly

Table 7. Effect of PGPR consortia on NPK content of plant and soil at the time of harvest

Sl. No.	Treatments	Nutrient (mg/plant)			Nutrient (mg/ha)		
		N	P	K	N	P	K
1	Control	254.33 e	190.33 g	166.33 h	215.00 h	23.00 g	144.67 g
2	RDF + *Acetobacter* (Aceto-5)	289.33 b	191.00 g	196.00 g	363.33 b	33.67 d	180.33 b
3	RDF + *Bacillus* (PSB-3)	232.33 f	204.00 e	215.00 f	227.00 f	27.83 f	176.00 c
4	RDF + *Bacillus* (KSB-3)	233.33 f	263.33 b	240.00 d	219.66 g	35.50 b	158.00 e
5	RDF + *Acetobacter* (Aceto-5) + *Bacillus* (PSB-3)	285.33 c	241.33 d	232.33 e	352.00 c	34.50 c	156.33 f
6	RDF + *Bacillus* (KSB-3) + *Bacillus* (PSB-3)	191.00 a	195.33 f	246.00 c	231.33 e	31.33 e	162.00 d
7	RDF + *Acetobacter* (Aceto-5) + *Bacillus* (KSB-3)	266.33 d	254.66 c	257.00 b	295.33 d	33.67 d	180.67 b
8	RDF + *Acetobacter* (Aceto-5) + *Bacillus* (KSB-3) + *Bacillus* (PSB-3)	297.33 a	285.00 a	259.00 a	372.33 a	38.00 a	191.33 a
	SEM ±	18.01	16.52	13.32	12.51	0.52	18.03
	CD @ 0.05%	2.61	2.54	2.42	2.30	1.89	3.00

Note: Absolute Control = Only Soil without compost or fertilizer treatment; RDF = Recommended Dose of Fertilizer; Means followed by the same letters do not differ significantly

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Enhancing the Post-Harvest Longevity and Quality of Ornamental Flowers for Decorations Using Household Paraffin Wax

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Untreated fresh floral decorations are easily subjected to loss their quality and appearance degradation when exposed to room temperature. There are so many methods to enhance the vase life and quality of ornamental flowers. But the problem is those flowers are quite expensive in commercial market. The undergo research was focused on to develop a low cost flower preservation method using household paraffin wax. Pure wax solution was prepared by melting household paraffin wax at 100^0c and maintained the temperature at 70 °C using a water bath. Selected flowers (Bougainville, *Plumaria acuminate*, Rose, Orchid) were submerged into the wax until entire up to the stem is covered. Then the flower was removed from the wax and it was gently shake to remove the excess wax. Just after dipping in the wax, flowers were dipped into cold water (20c). Waxed flowers kept in refrigerator in different durations (12hr, 24hr, 48hr and 72 hr). After kept in refrigerator they were kept under room condition for different durations (6 hr, 12 hr and 24 hr). Appearance was recorded according to a scale based on flower colour and quality. Result showed that the waxed flowers of Bougainville and Orchid are significantly very good when stored in a refrigerator for 12 and 24 hr. The waxed flowers which are stored at room temperature were not look attractive when compared with chilled flowers. Waxed and 24 hr chilled flowers of Bougainville and Orchid are significantly very good even after replacing in room temperature for 12, 24 and 48 hr. The waxed flowers which are stored at room temperature were not look attractive when compared with chilled flowers. Household wax at 70° can use as effective method of preserving flowers with good appearance and quality. To enhance the vase life of waxed flowers refrigeration / chilling can use.

Keywords: Household paraffin wax, Bougainville, Plumaria acuminate, Rose, Orchid

INTRODUCTION

Degradation of the quality and appearance of flowers is a problem found in fresh floral decorations. Petal wilting, petal drop and petal discoloration are the causes to reduce the economic value of floral decorations. Even though there are such methods to improve the quality and appearance of flowers, sometimes those are time consuming and economically not profitable (1-MCP, Ascorbic acid) (Obadamudalige *et al*.; 2014). There are many commercial florists who are preserving fresh flowers using various chemicals. But at market those flowers are very expensive. So it is important to find a low cost method to preserve flowers for floral decorations.

The objective of this study is to find an effective method to preserve flowers using household wax to extend the vase life and to improve the quality of the ornamental flowers.

MATERIALS AND METHODOLOGY

Fresh flowers of Bougainville species, *Plumaria acuminate*, Rose, Orchidwere collected from Matara district, Sri Lanka. Pure wax solution was prepared by melting household paraffin wax at 100 °C and maintained the temperature at 70 °C using a water bath. Colored wax solutions were prepared by melting household wax together with colourpastels (*Atlas*). Food colouringsolution (1:1) was prepared to dip *Plumaria accuminata* flowers. *Plumaria accuminata* flowers were

dipped in the food colouring solution and then coated with wax. These additional colouring methods were used to modify the flower colour of white colour orchids and P*lumariaaccuminata*.

Selected flowers were submerged into the wax until entire up to the stem is covered. Then the flower was removed from the wax and it was gently shake to remove the excess wax. Just after dipping in the wax, flowers were dipped into cold water. It helps to push the petals back as original flower and to accelerate the cool down. Then they were kept in cold water for 5 minutes. Wax applied flowers were kept for drain excess water and dry.

Waxed flowers kept in refrigerator in different durations (12 hr, 24 hr, 48 hr and 72 hr). After kept in refrigerator they were kept under room condition for different durations (6hr, 12hr, and 24hr). Appearance was recorded according to a scale given below based on flower colour and quality.

Very good - 1
Good - 2
Moderate - 3
Poor - 4

Completely Randomized Design (CRD) with five replicates was used for study. Statistical analysis was performed with Duncan's multiple range tests using SAS software (version 9.1.3).

RESULT AND DISCUSSION

Appearance just after waxing

Result showed that waxed flowers (Bougainville, Orchid, *Plumaria accuminata*, Rose) significantly very good in appearance and quality than natural flowers.

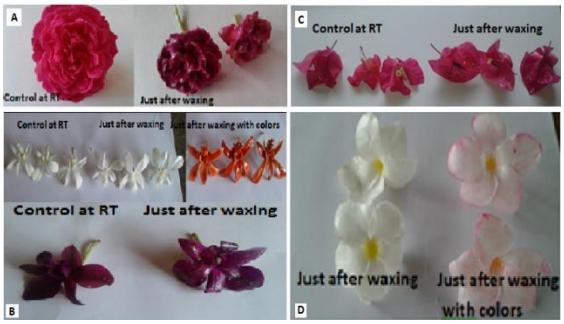

Fig. 1. Effect of waxing on storage of flower, appearance just after waxing. A) Waxing for roses; **B)** Waxing for orchids; **C)** Waxing for bougainville; **D)** Waxing for *Plumaria acculminata*.

Table 1. Effect of waxing on storage of flower

	Bougainville	Orchid	*Plumariaaccuminata*	Rose
Appearance just after waxing				
Waxed	1^a	1^a	1^a	1^a
Natural	3^b	3^b	3^b	3^b
After 12 hours of cooling time				
Chilled	1^a	1^a	1^a	1^a
Room temperature	3^b	3^b	3^b	3^b
After 24 hours of cooling time				
Chilled	1^a	1^a	-	-
Room temperature	3^b	3^b	-	-
After replacing the 24 hours chilled waxed flowers in to room temperature for 24 hours				
Waxed	1^a	1^a	-	-
Control (waxed but keep in room temperature)	3^b	3^b	-	-
After replacing the 24 hours chilled waxed flowers in to room temperature for 48 hours				
Waxed	1^a	1^a	-	-
Control (waxed but keep in room temperature)	3^a	3^b	-	-

*Mean values in each column superscripted by the same letters are not significantly different ($p>0.05$).

After 12 hours of cooling time

Result showed that the waxed flowers of Bougainville, Orchid, *Plumariaaccuminata* and Rose are significantly very good when stored in a refrigerator for 12 hours. The waxed flowers which are stored at room temperature were not

look attractive when compared with chilled flowers.

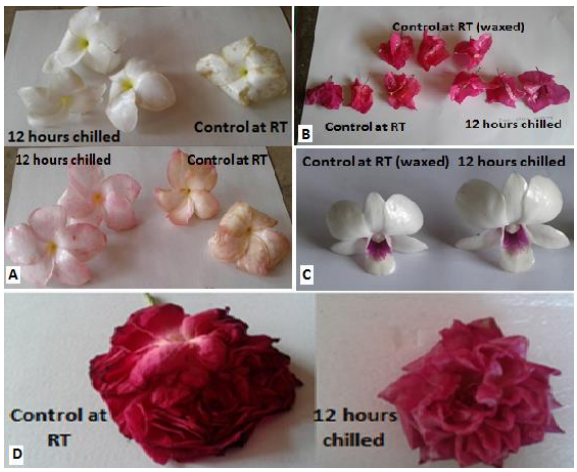

Fig. 2. Effect of waxing on storage of flower, appearance after 12 hours of waxing. A) Waxing for *Plumaria acculminata*; B) Waxing for bougainville; C) Waxing for orchids; D) Waxing for roses.

After 24 hours of cooling time

Result showed that the waxed flowers of Bougainville and Orchid are significantly very good when stored in a refrigerator for 24 hours. The waxed flowers which are stored at room temperature were not look attractive when compared with chilled flowers.

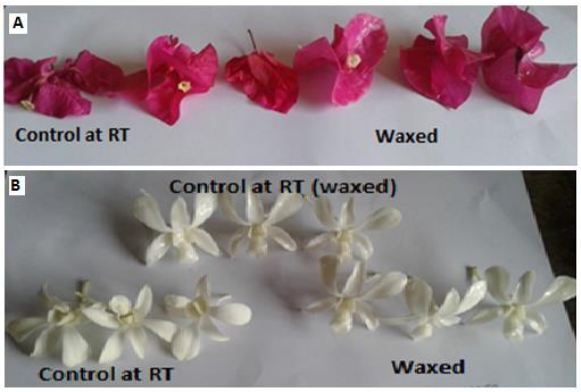

Fig. 3. Effect of waxing on storage of flower, appearance after 12 hours of waxing. A) Waxing for bougainville; **B)** Waxing for orchids.

After replacing the 24 hours chilled waxed flowers in to room temperature for 12 hours

Result showed that the waxed and 24 hours chilled flowers of Bougainville and Orchid are significantly very good even after replacing in room temperature for 12 hours. The waxed flowers which are stored at room temperature were not look attractive when compared with chilled flowers.

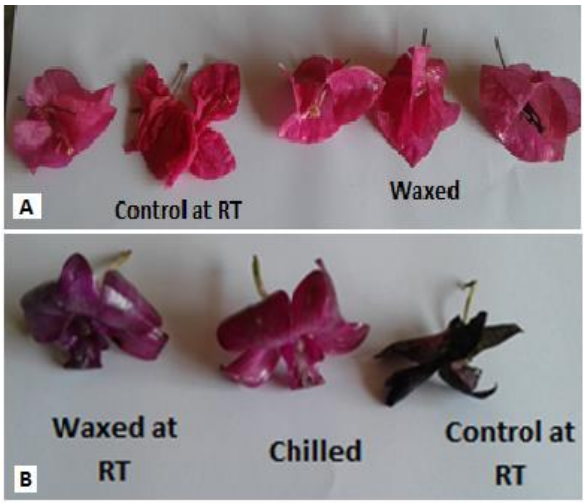

Fig. 4. Effect of waxing on storage of flower, after replacing the 24 hours chilled waxed flowers in to room temperature for 24 hours. A) Waxing for bougainville; **B)** Waxing for orchids.

After replacing the 24 hours chilled waxed flowers in to room temperature for 24 hours

Result showed that the waxed and 24 hours chilled flowers of Bougainville and Orchid are significantly very good even after replacing in room temperature for 24 hours. The waxed flowers which are stored at room temperature were not look attractive when compared with chilled flowers.

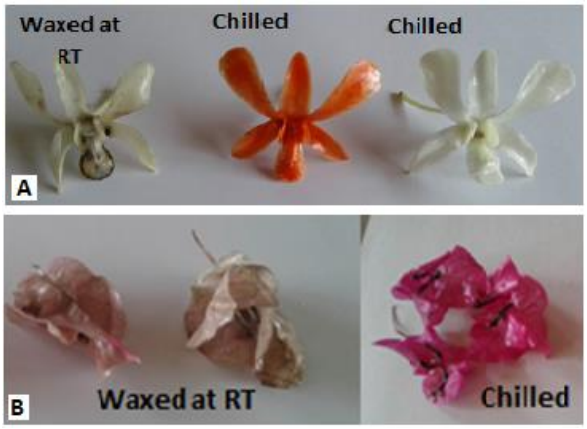

Fig. 4. Effect of waxing on storage of flower, after replacing the 24 hours chilled waxed flowers in to room temperature for 24 hours. A) Waxing for bougainville; **B)** Waxing for orchids.

After replacing the 24 hours chilled waxed flowers in to room temperature for 48 hours

Result showed that the waxed and 24 hours chilled flowers of Bougainville and Orchid are significantly very good even after replacing in room temperature for 48 hours. The waxed flowers which are stored at room temperature were not look attractive when compared with chilled flowers.

CONCLUSION

Household wax at 70 ^{o}C can use as effective method of preserving flowers with good appearance and quality. To enhance the vase life of waxed flowers refrigeration / chilling can use.

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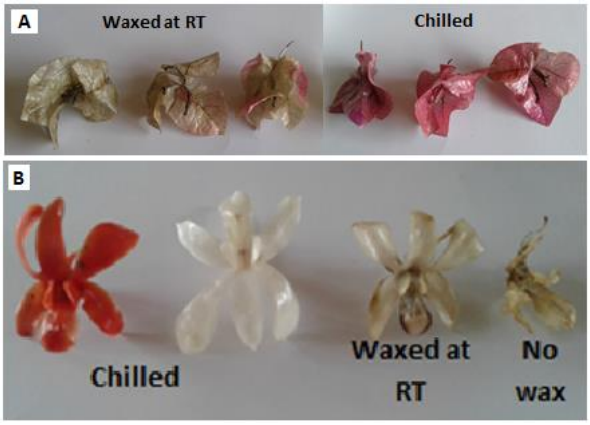

Fig. 5. Effect of waxing on storage of flower, after replacing the 24 hours chilled waxed flowers in to room temperature for 48 hours. A) Waxing for bougainville; **B)** Waxing for orchids.

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Effect of Pre-Drying Treatments, Drying Methods and Storage of Dehydrated Mature and Ripe Ber Fruits cv Kaithali and Umran on Non-Enzymatic Browning

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The study was conducted to standardize the method of dehydration of without stone fruits of cv. Kaithali and Umran at mature and ripe stages. Fruits were blanched before drying and were treated with SO_2 by burning of sulphur powder @ 2 g/kg *ber* fruits for two hours; boiled in 1% NaOH for 1 minute then boiled in 0.5% citric acid and finally dipped in KMS solution 4000 ppm for 12 hours and in control-fruits were kept untreated and unblanched for drying. Among pre drying treatments KMS treated fruits (Kaithali : mature 4.24, ripe 4.32; Umran : mature 3.27, ripe 3.97) recorded lowest non-enzymatic browning, followed by SO2 treated fruits however it was highest in untreated fruits in both the cultivars at each ripening stage. In drying methods, it was also recorded lowest (Kaithali : mature 4.45, ripe 5.59; Umran : mature 3.37, ripe 4.50) in oven dried fruits as compared sun dried fruits in in both the cultivars at each ripening stage. During the storage of dried ber fruits non-enzymatic browning increased with increase in storage period (Increase from beginning to six months of storage Kaithali : mature 2.90-7.14, ripe 3.18-7.09; Umran : mature 2.05-6.44, ripe 3.01-6.91).

Keywords: Ber, dehydration, potassium meta-bi-sulphite (KMS), sulpher di-oxide, non-enzymatic browning

INTRODUCTION

Ber (*Ziziphus mauritiana* Lamk.) is an ideal fruit for cultivation in arid and semi-arid regions of India. It is rich in nutritive value, popular and cheap, hence is often called as a poor man's fruit. It is a rich source of vitamin C (90-120 mg/100g). In fact, its vitamin C content is higher than apple, citrus and mango. *Ber* fruits are very rich in protein and minerals such as phosphorus and calcium. Besides being rich in nutritive value, it is regular and prolific bearer. It can be grown easily in a barren land and adverse climatic conditions, where most of other fruit plants cannot be grown successfully. The recent statistics of India reveals that it occupies 56 thousand ha area with a production of 584000 MT (Anonymous, 2015).

The *ber* fruits are mostly consumed fresh but due to higher production of *ber* during the season, there is glut in the market and the farmer gets low price for his produce. Moreover, the post-harvest losses in our country are about 20 to 30 per cent because of poor post harvest management practices and lack of proper storage and cool chain transportation facility. The increased production of *ber* fruit needs to be supplemented by the proper utilization that would be achieved through preservation, drying and processing.

Processed products have food palatability, acceptability and shelf life. The

processing technique should not lead to appreciable nutrient losses and those lost need to be fortified. Several fruits are processed in India in the form of different products. Most common processed products are preserve, dehydrated fruit, canned fruit, juice, pulp, squash, wine and fruit candy. Among the dehydration is an ancient products it can be utilized round the year. This helps to ease out fluctuation in the market price and farmers may get better returns and consumers get value added products. These products of *ber* have good acceptability and can fetch good price in the market.

Methods for processing and preservation of different fruits have been standardized by several workers (Girdhari Lal *et al.,* 1986; Kordylas, 1991; Srivastava, 1992; Srivastava and Kumar, 2003). Drying has been an ancient technique in India for preservation of fruits and vegetables. Dried fruits are utilized directly or for making value added products during off-season and at a place where a particular commodity is not grown and in remote places for army personnel.

Browning is usually accompanied by change in flavour, odour and nutritive value. It adversely affect the colour and texture. The permitted limit of SO_2 is 1500 to 2000 ppm to check browning during drying of fruits (Vijaya *et al*., 1979) cannot completely stop browning reactions. But it can check micro-organisms and browning sufficiently to keep the dried products acceptable for about a year at 21^0C (Nury *et al*., 1960). Hayati (1987) recorded the gradual increase in browning of guava pulp during storage and the rate of increase was higher at higher temperature. During storage of *ber* candy an increase in browning was also observed by Gupta *et al.* (1980). The trend of increase in browning was also reported by Chan and Cavaletto (1986) in papaya puree during storage and Sethi and Anand (1982) in carrot preserve during storage.

Sun drying was done in wooden trays of 3′ x 2′ size were used for sun drying. The fruits were spread on the muslin cloth lined in wooden trays lined with muslin cloth and trays were kept under the sun (maximum day temperature was 35±2 °C). The trays were shaked 3-4 times daily in order to achieve uniform drying. Trays were kept in laboratory during night period.

MATERIALS AND METHODS

The experiment on standardization of dehydration techniques was carried out in the post-harvest technology laboratory and fruits at mature and ripe stage fruits of cultivar Umran and Kaithali were collected from the experimental orchard Department of Horticulture, CCS Haryana Agricultural University, Hisar. Fruits of mature stage were harvested when there was no further increase in size and fruits start changing colour from green to yellowish and ripe fruits were harvested when fruits changed from yellowish to brown colour. Pre drying treatments such as Blanching + Sulfuring (2g/kg fruits), Blanching + KMS (Potassium meta bi-sulphide dip) 4000ppm and Untreated/Control. In Blanching fruits were dipped in boiling water for 2-3 minutes (2 minutes for Kaithali and 3 minutes for Umran) to inactivate the peroxidase enzyme activity. The test was conducted by adding 5ml of 0.25 per cent 0- dianisidine (prepared in 50% ethanol) on a 10g portion of cut fruit tissue in a white porcelain dish. The absence of development of a radish brown colour within two minutes indicated a negative test of peroxidase, which has been destroyed during process of blanching. In Sulphuring the Blanched fruits were fumigated for two hours with SO_2 gas (Burning of sulphur powder @ 2g/kg fruits) in a air tight chamber. Fruits were spread in density of 1kg/ft^2 in a tray with wooden slates in a chamber.

Lye peeling of fruits was done by dipping in boiling lye solution @ 1% NaOH for one minute. Lye peeled fruits were washed thoroughly in running water and then dipped in citric acid (0.5 %) for one minute to neutralize any trace of lye and finally washed in running water. After lye peeling, fruits were dipped in 4000 ppm KMS solution for 12 hours. Stones were removed as per treatment with the help of cork borer. The diameter of the cork borer was approximate to the thickness of stone.

After pre drying treatments the fruits were dried in sun and oven. In Sun drying, the fruits were kept in wooden trays of 3′x2′ size lined with muslin cloth (maximum day temperature was 35±2 °C) for sun drying. The trays were shaked 3-4 times daily in order to achieve uniform drying. Trays were kept in laboratory during night period. For oven drying the tray dryer (Micro Scientific work, MSW 216) having capacity of 18 trays was used. It had a fan and motor to circulate air

inside the dryer. The fruits were spread on trays in a single layer and dried at 55^0C temperature. The non- enzymatic browning was estimated by the increase in absorbance at 440 nm as described by Ranganna (1977). It was calculated as:

Non-enzymatic browning = [(OD value X Dilution factor)-OD of fresh fruit]

The data regarding non-enzymatic browning of dried *ber* fruits in relation to different pre-drying treatments (*viz*., untreated/control, SO_2 and KMS) of cv. Kaithali and Umran at both the stages of harvest was evaluated at monthly intervals up to six months of storage. The statistical analysis was conducted by completely randomize block design using methods given by Panse and Sukhatme, 1967.

RESULTS AND DISCUSSION

Drying of mature fruits of cv. Kaithali

Among the drying methods, sun dried fruits recorded more (4.88) non-enzymatic browning as compared to oven dried fruits (4.45) irrespective of pre-drying treatments and storage period (Table 1). Among pre-drying treatments of dried *ber* fruits minimum (4.24) non-enzymatic browning was recorded in KMS treated fruits whereas, maximum (5.32) non-enzymatic browning was observed in untreated/control fruits irrespective of drying methods and storage period. During storage of dried *ber* fruits non-enzymatic browning increased from 2.90 to 7.14 with the increase in storage period from beginning of storage to 6 months of storage irrespective of pre-drying treatments and drying methods.

In interaction of pre-drying treatments with drying methods, minimum (4.06) non-enzymatic browning was recorded in oven dried KMS treated fruits whereas, maximum (5.56) non-enzymatic browning was recorded in sun dried control/untreated fruits irrespective of storage period. Among the drying methods, non-enzymatic browning increased from 3.00 to 7.51 in sun dried fruits and 2.81 to 6.76 in oven dried fruits from beginning of storage to 6 months of storage irrespective of pre-drying treatments.

Non-enzymatic browning also increased with increase in storage period in each pre-drying treatment, maximum (8.14) non-enzymatic browning was recorded in untreated/control fruits after 6 months of storage whereas, minimum (2.62) non-enzymatic browning was recorded in KMS treated fruits at the beginning of storage irrespective of drying methods. In interaction of drying methods with pre-drying treatments and storage period, KMS treated oven dried fruits recorded lowest (2.53) non-enzymatic browning at the beginning of storage whereas, it was recorded highest (8.48) in control/untreated sun dried fruits after 6 months of storage.

Table 1. Effect of dehydration methods, pre-drying treatments and storage period on non-enzymatic browning of mature *ber* fruits of cv. Kaithali

Pre-drying	Storage Period (Months)							
Treatments	0	1	2	3	4	5	6	Mean
Sun Dry								
Control	3.37	3.87	4.28	5.40	6.23	7.31	8.48	5.56
SO_2	2.92	3.36	4.07	4.51	4.98	5.66	7.18	4.67
KMS	2.70	3.17	3.78	4.21	4.82	5.39	6.87	4.42
Mean	3.00	3.47	4.04	4.71	5.34	6.12	7.51	4.88
Oven Dry								
Control	3.17	3.62	4.12	4.81	5.48	6.58	7.79	5.08
SO_2	2.72	3.11	3.37	4.12	4.51	5.28	6.37	4.21
KMS	2.53	2.98	3.26	3.94	4.33	5.24	6.12	4.06
Mean	2.81	3.24	3.58	4.29	4.77	5.70	6.76	4.45
Mean Table (Pre-drying Treatments x Storage)								
Control	3.27	3.74	4.20	5.11	5.86	6.95	8.14	5.32
SO_2	2.82	3.24	3.72	4.32	4.75	5.47	6.78	4.44
KMS	2.62	3.08	3.52	4.08	4.58	5.32	6.50	4.24
Mean	2.90	3.35	3.81	4.50	5.06	5.91	7.14	

CD (P≤0.05); Drying Methods = 0.22; Pre-drying Treatments = 0.26; Storage = 0.41; Drying Methods X Pre-drying Treatments = 0.45; Drying Methods X Storage = 0.60; Pre-drying Treatments X Storage = 0.65; Drying Methods X Pre-drying Treatments X Storage = 0.95

Drying of ripe fruits of cv. Kaithali

Among the drying methods, sun dried fruits recorded more (5.09) non-enzymatic browning than oven dried fruits (4.59) irrespective of pre-drying treatments and storage period (Table 2). Dried *ber* fruits recorded minimum (4.32) non-enzymatic browning in KMS treated fruits whereas, it was observed maximum (5.73) in untreated/control fruits irrespective of drying methods and storage period. Non-enzymatic browning of dried *ber* fruits increased from 3.18 to 7.09 with increase in storage period from beginning of storage to 6 months of storage irrespective of pre-drying treatments and drying methods.

Table 2. Effect of dehydration methods, pre-drying treatments and storage period on non-enzymatic browning of ripe *ber* fruits of cv. Kaithali

Pre-drying	Storage Period (Months)							
Treatments	0	1	2	3	4	5	6	Mean
Sun Dry								
Control	3.82	3.99	4.48	5.88	7.18	8.21	10.01	6.22
SO_2	3.23	3.44	3.89	4.46	5.22	5.58	6.44	4.61
KMS	3.04	3.32	3.81	4.28	5.01	5.41	6.23	4.44
Mean	3.36	3.58	4.06	4.87	5.80	6.40	7.56	5.09
Oven Dry								
Control	3.37	3.78	4.21	4.96	5.42	6.72	8.23	5.24
SO_2	2.88	3.36	3.61	4.37	4.92	5.38	5.88	4.34
KMS	2.73	3.17	3.52	4.21	4.75	5.23	5.72	4.19
Mean	2.99	3.44	3.78	4.51	5.03	5.78	6.61	4.59
Mean Table (Pre-drying Treatments x Storage)								
Control	3.60	3.89	4.35	5.42	6.30	7.47	9.12	5.73
SO_2	3.06	3.40	3.75	4.42	5.07	5.48	6.16	4.48
KMS	2.89	3.25	3.67	4.25	4.88	5.32	5.98	4.32
Mean	3.18	3.51	3.92	4.69	5.42	6.09	7.09	

CD ($P \leq 0.05$); Drying Methods = 0.18; Pre-drying Treatments = 0.21; Storage = 0.37; Drying Methods X Pre-drying Treatments = 0.39; Drying Methods X Storage = 0.57; Pre-drying Treatments X Storage = 0.60; Drying Methods X Pre-drying Treatments X Storage = 0.92

In interaction of pre-drying treatments with drying methods, minimum (4.19) non-enzymatic browning was recorded in oven dried KMS treated fruits whereas, maximum (6.22) non-enzymatic browning was recorded in sun dried control/untreated fruits irrespective of storage period. Among the drying methods, non-enzymatic browning increased from 3.36 to 7.56 in sun dried fruits and 2.99 to 6.61 in oven dried fruits from beginning of storage to 6 months of storage irrespective of pre-drying treatments.

Non-enzymatic browning increased with increase in storage period in each pre-drying treatments, maximum (9.12) non-enzymatic browning was recorded in untreated/control fruits after 6 months of storage whereas, minimum (2.89) non-enzymatic browning was recorded in KMS treated fruits at the beginning of storage irrespective of drying methods. In case of interaction of drying methods with pre-drying treatments and storage period, KMS treated oven dried fruits recorded lowest (2.73) non-enzymatic browning at the beginning of storage whereas, it was recorded highest (10.01) in control/untreated sun dried fruits after 6 months of storage.

Drying of mature fruits of cv. Umran

Among the drying methods, sun dried fruits recorded more (4.49) non-enzymatic browning than oven dried fruits (3.37) irrespective of pre-drying treatments and storage period (Table 3). In pre-drying treatments of dried *ber* fruits minimum (3.27) non-enzymatic browning was recorded in KMS treated fruits whereas, maximum (4.98) non-enzymatic browning was observed in untreated/control fruits irrespective of drying methods and storage period. During

storage of dried *ber* fruits non-enzymatic browning increased from 2.05 to 6.44 with increase in storage period from beginning of storage to 6 months of storage irrespective of pre-drying treatments and drying methods.

Table 3. Effect of dehydration methods, pre-drying treatments and storage period on non-enzymatic browning of mature *ber* fruits of cv. Umran

Pre-drying	Storage Period (Months)							
Treatments	0	1	2	3	4	5	6	Mean
Sun Dry								
Control	2.89	3.45	4.09	5.27	6.42	8.01	9.89	5.72
SO_2	2.43	2.81	3.42	4.08	4.49	4.98	5.87	4.01
KMS	2.21	2.48	3.28	3.86	4.27	4.77	5.41	3.75
Mean	2.51	2.91	3.60	4.40	5.06	5.92	7.06	4.49
Oven Dry								
Control	2.09	2.57	3.12	3.78	4.67	5.41	7.99	4.23
SO_2	1.45	1.72	2.49	2.98	3.59	4.39	5.03	3.09
KMS	1.22	1.42	2.16	2.70	3.41	4.12	4.42	2.78
Mean	1.59	1.90	2.59	3.15	3.89	4.64	5.81	3.37
Mean Table (Pre-drying Treatments x Storage)								
Control	2.49	3.01	3.60	4.53	5.55	6.71	8.94	4.98
SO_2	1.94	2.27	2.96	3.53	4.04	4.69	5.45	3.55
KMS	1.72	1.95	2.72	3.28	3.84	4.45	4.92	3.27
Mean	2.05	2.41	3.09	3.78	4.48	5.28	6.44	

CD (P≤0.05); Drying Methods = 0.12; Pre-drying Treatments = 0.16; Storage = 0.34; Drying Methods X Pre-drying Treatments = 0.36; Drying Methods X Storage = 0.51; Pre-drying Treatments X Storage = 0.55; Drying Methods X Pre-drying Treatments X Storage = 0.87

As regards interaction of pre-drying treatments with drying methods, minimum (2.78) non-enzymatic browning was recorded in oven dried KMS treated fruits whereas, maximum (5.72) non-enzymatic browning was recorded in sun dried control/untreated fruits irrespective of storage period. Among the drying methods, non-enzymatic browning increased from 2.51 to 7.06 in sun dried fruits and 1.59 to 5.81 in oven dried fruits from beginning of storage to 6 months of storage irrespective of pre-drying treatments.

The maximum (8.94) non-enzymatic browning was recorded in untreated/control fruits after 6 months of storage whereas, minimum (1.72) non-enzymatic browning was recorded in KMS treated fruits at the beginning of storage irrespective of drying methods. In case of interaction of drying methods with pre-drying treatments and storage period, KMS treated oven dried fruits recorded the lowest (1.22) non-enzymatic browning at the beginning of storage whereas, it was recorded highest (9.89) in control/untreated sun dried fruits after 6 months of storage.

Drying of ripe fruits of cv. Umran

Among drying methods, sun dried fruits recorded more (5.02) non-enzymatic browning than oven dried fruits (4.50) irrespective of pre-drying treatments and storage period (Table 4). In pre-drying treatments of dried fruits minimum (3.97) non-enzymatic browning was recorded in KMS treated fruits whereas, maximum (6.00) non-enzymatic browning was observed in untreated/control fruits irrespective of drying methods and storage period. The storage of dried *ber* fruits increased non-enzymatic browning from 3.01 to 6.91 with increase in storage period from beginning of storage to 6 months of storage irrespective of pre-drying treatments and drying methods

Table 4. Effect of dehydration methods, pre-drying treatments and storage period on non-enzymatic browning of ripe *ber* fruits of cv. Umran

Pre-drying	Storage Period (Months)							
Treatments	0	1	2	3	4	5	6	Mean
Sun Dry								
Control	3.53	4.11	4.81	6.14	7.39	8.49	10.33	6.40
SO_2	3.03	3.41	4.23	4.49	5.22	5.52	6.08	4.57
KMS	2.85	3.17	3.59	4.12	4.48	4.99	5.39	4.08
Mean	3.14	3.56	4.21	4.92	5.70	6.33	7.27	5.02
Oven Dry								
Control	3.23	3.74	4.40	5.09	6.01	7.99	8.68	5.59
SO_2	2.77	3.16	3.54	3.88	4.47	5.08	5.54	4.06
KMS	2.64	2.96	3.42	3.69	4.18	4.67	5.42	3.85
Mean	2.88	3.29	3.79	4.22	4.89	5.91	6.55	4.50
Mean Table (Pre-drying Treatments x Storage)								
Control	3.38	3.93	4.61	5.62	6.70	8.24	9.51	6.00
SO_2	2.90	3.29	3.89	4.19	4.85	5.30	5.81	4.32
KMS	2.75	3.07	3.51	3.91	4.33	4.83	5.41	3.97
Mean	3.01	3.43	4.00	4.57	5.29	6.12	6.91	

CD (P≤0.05); Drying Methods = 0.24; Pre-drying Treatments = 0.28; Storage = 0.45; Drying Methods X Pre-drying Treatments = 0.46; Drying Methods X Storage = 0.62; Pre-drying Treatments X Storage = 0.67; Drying Methods X Pre-drying Treatments X Storage = 0.99

In interaction of pre-drying treatments with drying methods, minimum (3.85) non-enzymatic browning was recorded in KMS treated oven dried fruits whereas, maximum (6.40) non-enzymatic browning was recorded in control/untreated sun dried fruits irrespective of storage period. Among the drying methods, non-enzymatic browning increased from 3.14 to 7.27 in sun dried fruits and 2.88 to 6.55 in oven dried fruits from beginning of storage to 6 months of storage irrespective of pre-drying treatments.

Non-enzymatic browning also increased significantly with increase in storage period in each pre-drying treatment, maximum (9.51) non-enzymatic browning was recorded in untreated/control fruits after 6 months of storage whereas, minimum (2.75) non-enzymatic browning was recorded in KMS treated fruits at the beginning of storage irrespective of drying methods. In case of interaction of drying methods with pre-drying treatments and storage period, KMS treated oven dried fruits recorded lowest (2.64) non-enzymatic browning at the beginning of storage whereas, it was recorded highest (10.33) in control/untreated sun dried fruits after 6 months of storage.

Non-enzymatic browning of *ber* fruits (Table 1-4) increased with increase in storage period. Similar studies of increase in non-enzymatic browning of ber powder during storage period of 90 days was also observed by Kumar et al. (2009). Nonenzymatic browning (NEB) reactions occur during the thermal processing and storage of foods. These reactions cause some desirable and undesirable chemical and structural changes in foods. The mostly known changes are formation of brown color, production of flavors or off-flavors, nutritional loss followed by the reduction of ascorbic acid, amino acids, and invert sugars, and formation of some toxic and mutagenic compounds such as imidazols, HMF, acrylamide, advanced glycation endproducts (pentosidine and argpyrimidine), and melanoidines (Gogus et al., 2010). This was mainly due to non-enzymatic reaction such as organic acid with sugar or oxidation of phenol, which leads to formation of brown pigment. Decline in ascorbic acid content of the fruit products may be one of the possible reasons for browning of the products (Kumar, 1990). Kalsi (1998) also reported the increase in browning of guava powder during storage. Similar results were observed by Murlikrishna *et al*. (1969) in storage of guava powder and noticed that non-enzymatic browning increased with increase in storage temperature.

Treatments like SO_2 and KMS reduced the non-enzymatic browning of the dried *ber*

fruits due to inactivation of enzymes during blanching and addition of antioxidants (Ranganath and Dubash, 1981). Less non-enzymatic browning has also been reported by Khurdiya (1980) in *ber* samples when exposed to fumes of burning sulphur. Among dehydration methods, sun dried fruits recorded more non-enzymatic browning than oven dried fruits. The oven dried KMS treated mature fruits of cv. Kaithali as well as mature and ripe fruits of cv. Umran treated with KMS and SO_2 recorded light brown colour. Dhawan (1980) also observed better colour of *ber* fruits dehydrated in hot air oven. Non-enzymatic reactions and oxidation of various phenolic and other compounds are responsible for the formation of browning pigments and the loss of ascorbic acid may also be one of the reasons for increase in non-enzymatic browning (Fenemma, 1976).

Summery

Sun dried fruits revealed more non-enzymatic browning than oven dried fruits. It increased with increase in storage period with respect to pre-drying treatments and drying methods. Among the pre-drying treatments, KMS treated fruits recorded lowest non-enzymatic browning succeeded by SO_2 and untreated/control fruits. Minimum non-enzymatic browning was observed in KMS treated oven dried *ber* fruits after 6 months of storage. It is therefore, concluded from the present study that the dehydrated fruits pretreated KMS recorded minimum non-enzymatic browning.

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Effect of Sowing Dates and Pulses in Relay Cropping with T. Aman Rice in High Barind Tract of Bangladesh

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An experiment was carried out at farmer's field of FSRD (Farming System Research and Developement) site, Kadamshahar, Godagari, Rajshahi during the season 2013-14 to find out the optimum sowing date for growing different pulses as relay with T.Aman rice and to observe the suitable one to grow with T.Aman rice as relay in High Barind Tract of Bangladesh. There were three treatments and six dispersed replications. The study was designed with RCB and sowing dates were 15, 10 and 5 days before harvesting of T.Aman rice and pulses were lentil (BARI Masur-6), grass pea (BARI Khesari-1) and mustard (BARI Sharisha-14). The yield and yield components of lentil, grass pea and mustard were significantly influenced by the different sowing dates. Treatment T_1 (15 day before harvest of T.Aman rice) produced the maximum grain yield 0.937 t ha^{-1} for lentil, 1.42 t ha^{-1} for grass pea and 1.12 t ha^{-1} for mustard. The highest economic return was found with treatment T_1 (15 day before harvest of T.Aman rice). It produced the maximum gross margin of 551.93 \$ ha^{-1} for lentil, 506.87 \$ $ha^{-1}$for grass pea and 328.75 \$ $ha^{-1}$for mustard, although its variable cost was 209.38 \$ $ha^{-1}$for lentil, 203.13 \$ $ha^{-1}$for grass pea and 231.25 \$ $ha^{-1}$for mustard during 2013-14 . So, the treatment T_1 (15 day before harvest of T.Aman rice) was optimum for maximizing the yield as well as economically profitable and viable for relay lentil with T.Aman rice in High Barind Tract soil.

Keywords: Sowing dates, Pulses, T.Aman rice, High Barind Tract

INTRODUCTION

High Barind Tract is the part of north-west Rajshahi division experienced high temperature with limited soil moisture storage along with low and erratic rainfall. Moisture holding capacity of HBT soil is poor due to critical organic matter contents and low infiltration of water. Farmers normally grow only one crop of T .Aman rice under rainfed condition in each year. They cultivate long duration T. Aman rice which takes long time to mature and normally harvested at the end of November to first week of December. Land remains fallow after that, as soil does not contain adequate moisture for growing *Rabi* crops. For this reason, farmers of the area have started to grow some *rabi* crops viz., lentil, grass pea, mustard, etc. as relay crop with T. Aman rice. However, information on suitable time and appropriate crop for relay cropping with T. Aman rice in High Barind Tract is inadequate. The average yield of T. Aman in HBT is low compared to other parts of the country. The factors responsible for this gap are variety, seed quality, soil, climate and nutrient management (Elias *et. al.,* 1991). It is primarily due to low fertility status of soils, imbalanced use of fertilizers and small or no manure application. Most of the farmers usually do not apply fertilizers in balanced proportions (BARC, 2005). In Bangladesh, pulses play a vital role in agriculture as well as in human diets. Now a days national pulse production within rice based system is declining dramatically day by day because of competition with the other winter

crops like wheat, maize, boro rice, potato and vegetables. But the demand of pulses is increased continuously. As a source of plant protein, the reduction of pulses production is a major concern of the government. Lentil (*Lens culinaries* L.) is one of the most important winter pulse grown in Bangladesh. It plays an important role in human diet and also in improving soil fertility by fixing atmospheric nitrogen. The lentil is a crop which can provide both biomass and seed at a time. Lentil can be fitted into the Rice-mungbean-T. Aman cropping pattern. A crop production system with high yield targets can't be sustainable unless balanced nutrient inputs are supplied to soil against nutrient removal by crops (Bhuiyan *et. al.,* 1991). Again, unless the organic matter factor is adequately considered in the cropping systems, increased yield and sustained soil productivity may not be possible (Saha *et. at*., 1998). Legumes are considered to be an important component of subsistence cropping systems because of their ability to form nodules, to add substantial amount of nitrogen and organic matter to the soil. The global concern about sustainable agricultural systems further highlights the significance of legumes, which offer a renewable source of energy through biological nitrogen fixation (Timsina *et al*., 2002). Recently Bangladesh Agricultural Research Institute (BARI) has developed and released some high yielding varieties of lentil. It should need to disseminate these newly released lentil varieties among the farmers. Considering these points, the present demonstration trial was under taken to popularize the high yielding, lentil verities among the growers and there by generate the income of the rural people of the country. To increase national pulses production, this project will fit short duration pulses (lentil, mungbean and field pea) into new cropping niches in western Bangladesh. Therefore, the present study will be carried out with the following objectives. i)To find out the optimum sowing time for growing different pulses as relay with T. Aman rice and ii)To observe the suitable one to grow with T. Aman rice as relay.

MATERIALS AND METHODS

The experiment was conducted at FSRD site, Kadamshahar, Godagari, Rajshahi during rabi season, 2013-14. Treatments: sowing date T_1= 15 days before harvest of T. rice, T_2= 10 days before harvest of T. Aman rice and T_3= 5 days before harvest of T. Aman rice. The size of experimental plot was about 4 m × 5 m with 6 dispersed replications. The study was designed with RCB and sowing time were 5, 10 and 15 days before harvest of T. Aman rice and crops of lentil (BARI Masur-6), grass pea (BARI Khesari-1) and Mustard (BARI Sharisha-14). Seeds were soaked overnight for ease of germination. The fertilizers were applied STB fertilizer doses (FRG 2005). The seed rate was 7 kg ha^{-1} for mustard, lentil 38 kg ha^{-1} and 45 kg ha^{-1} for grass pea. No weeding but three times fungicides (Rovral 50 WP) spraying were done starting from at the time of flowering. Mustard, lentil and grasspea were harvested on 25-30 January 2014, 20-28 February 2014 & 10-15 March 2014, respectively. All the data were statistically analyzed following the F-test and the mean comparisons were made by DMRT at 5% level (Gomez and Gomez, 1984). The economic analysis was done for gross return, gross margin and marginal benefit cost ratio over control of different sowing dates following the method suggested by Perrin *et al*. (1979).

RESULTS AND DISCUSSION

Soil moisture regime

Soil moisture percentage of the trial varied sowing dates. Soil moisture in the minimum tilled plots with sowing of lentil, grass pea and mustard just after harvest of T. Aman rice decreased at slower rates followed by minimum tilled plots with sowing of 5 days before harvest of T. Aman rice (Table 1). On the other hand, second treatments plots with sowing of lentil, grass pea and mustard at 10 days after harvest of T. Aman rice decreased at higher rates. Early sowing and minimum tillage helped keep the surface evaporation minimal.

Table 1. Changes in soil moisture (%) of lentil, grass pea and mustard field as influenced by various treatments at different days after sowing

Treatment	Days after sowing (DAS)				
	0	15	30	45	60
T_1	32.50	26.22	20.2	14.5	12.5
T_2	25.12	21.20	18.5	12.5	11.3
T_3	20.22	18.15	13.2	10.9	10.2

Yield and yield components of lentil responded significantly to different sowing date after harvest of T. Aman rice (Table 2). The maximum plant height of 32.77 cm was found in the treatment T_1 which was statistically different with treatment T_2 (28.70 cm) and minimum of 24.63 cm was observed in treatment T_3. The maximum number of plant m^{-2} (106.75) was found in T_1 followed by treatment T_2 (93.75). The minimum number of plant m^{-2} (71) was found in T_3 treatment. The maximum number of pods plant^{-1} (60.02) was obtained from treatment T_1 followed by treatment T_2 (46.37) and the minimum (36.31) was in treatment T_3. The maximum number of seeds pods^{-1} (1.90) and thousand seed weight (15.10 g) was obtained from early sowing treatment (T_1). The maximum seed and stover yield (o.937 t ha^{-1} and 1.79 t ha^{-1}) was obtained from treatment T_1 and minimum (o.618 t ha^{-1} and 0.853 t ha^{-1}) in late sowing treatment (T_3).

Table 2. Yield and yield component of relay crops lentil as influenced by different sowing date before harvest of T. Aman rice during *rabi* season 2013-2014

Treatments	Plant height (cm)	No. of plant m^{-2}	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000- seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1	32.77 a	106.75 a	60.02 a	1.90 a	15.10 a	937.00 a	1.790 a
T_2	28.70 ab	93.75 a	46.37 b	1.55 b	14.46 ab	843.00 a	1.630 b
T_3	24.63 b	71.00 b	36.31 c	1.10 c	12.99 b	618.00 b	0.853 c
CV (%)	13.35	13.53	3.50	7.29	6.63	8.52	1.30

Treatments: sowing date T_1= 15 days before harvest of T.Aman rice, T_2= 10 days before harvest of T.Aman rice and T_3= 5 days before harvest of T. Aman rice

Yield and yield components of grass pea responded significantly to different sowing date after harvest of T. Aman rice (Table 3). The maximum plant height of 47.50 cm was found in the treatment T_1 which was statistically different with treatment T_2 (45.50 cm) and minimum of 37.75 cm was observed in treatment T_3. The maximum number of plant m^{-2} (69.75) was found in T_1 followed by treatment T_2 (65.00). The minimum number of plant m^{-2} (44.00) was found in T_3 treatment. The maximum number of pods plant^{-1} (41.25) was obtained from treatment T_1 followed by treatment T_2 (31.50) and the minimum (25.50) was in treatment T_3. The maximum number of seeds pods^{-1} (4.70) and thousand seed weight (66.14 g) was obtained from early sowing treatment (T_1). The maximum seed and stover yield (1.42 t ha^{-1} and 1.680 kg ha^{-1}) was obtained from treatment T_1 and minimum (o.78 t ha^{-1} and 1.13 t ha^{-1}) in late sowing treatment (T_3).

Table 3: Yield Yield and yield component of relay crops grasspea as influenced by different sowing date before harvest of T.Aman rice during *rabi* season 2013-2014

Treatment	Plant height (cm)	No. of plant m^{-2}	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000- seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1	47.50 a	69.75 a	41.25 a	4.70 a	66.14 a	1.42 a	1.68 a
T_2	45.50 a	65.00 a	31.50 b	4.12 a	65.28 b	1.31 a	1.35 b
T_3	37.75 b	44.00 b	25.50 c	3.27 b	64.28 c	0.78 b	1.13 b
CV (%)	9.58	5.91	4.04	8.87	1.61	6.51	10.35

Treatments: sowing date T_1= 15 days before harvest of T. Aman rice, T_2= 10 days before harvest of T. Aman rice and T_3= 5 days before harvest of T. Aman rice

Yield and yield components of mustard responded significantly to different sowing date after harvest of T. Aman rice (Table 4). The maximum plant height of 66.75 cm was found in the treatment T_1 which was statistically identical with T_2. The maximum number of siliqua plant^{-1} (20.55) was obtained from treatment T_1 followed by T_2 (15.92) and the minimum (13.30) was in treatment T_3. The maximum number of seeds siliqua^{-1} (28.05) and thousand seed weight (2.76

g) was obtained from treatment T_1. The maximum seed(1.6 t ha^{-1}) and stover yield (2.51 t ha^{-1}) was obtained from treatment T_1 and minimum (0.77 t ha^{-1} and 1.89 t ha^{-1}) in late sowing treatment (T_3).

Table 4: Yield and yield component of relay crops mustard as influenced by different sowing date before harvest of T.Aman rice during *rabi* season 2013-2014

Treatment	Plant height (cm)	No. of plant/m^{-2}	No. of siliqua/ plant	No. of seeds/ siliqua	1000-seed weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	66.75 a	61.75 a	20.55 a	28.05 a	2.76 a	1.120 a	2.51 a
T_2	53.25 b	58.25 a	15.92 b	21.85 b	2.60 a	1.000 b	2.02 b
T_3	47.50 b	49.50 b	13.30 b	17.97 c	2.16 b	0.770 c	1.89 b
CV (%)	9.67	6.89	13.01	6.76	3.89	3.09	9.15

Economics

Gross return, variable cost, gross margin and marginal benefit-cost ratio over control of different treatment for relay crops have been shown in Table 5. The economic analysis of the experiment exhibited that treatment T_1 produced the maximum gross margin of 551.93 \$ ha^{-1} for lentil, 506.87 \$ $ha^{-1}$for grass pea and 328.75 \$ $ha^{-1}$for mustard for the year 2013-14, although its variable cost was 209.38 \$ ha^{-1}, 203.13 \$ ha^{-1} and 231.25 \$ ha^{-1}, respectively. The second highest gross margin of 475.55 \$ ha^{-1}, 451.87 \$ ha^{-1} & 271.25 \$ $ha^{-1}$for lentil, grass pea & mustard, respectively. This variation occurred due to the variation of grain yield. On the other hand, the maximum BCR was found in treatment T_1 that was 3.63 for lentil, 3.49 for grass pea and 2.42 for mustard which closely followed by treatment T_2. Karim *et al.* (1994) reported that farmers always try to maximize their returns up to the point where returns to investment are the highest as the capital is scarce. Thus farmers of the area may be advised to go for treatment T_1. The marginal farmers who are unable to afford necessary cost may choose T_1.

Table 5. Cost and return analysis for pulses during *rabi* season 2013-2014

Treatments	Crops	Seed yield (t ha^{-1})	Gross return (\$ ha^{-1})	Total variable cost (\$ ha^{-1})	Gross margin(\$ ha^{-1})	BCR
T_1	Lentil	0.937	761.31	209.38	551.93	3.63
	Grass pea	1.42	710.00	203.13	506.87	3.49
	Mustard	1.12	560.00	231.25	328.75	2.42
T_2	Lentil	0.843	684.93	209.38	475.55	3.27
	Grass pea	1.31	655.00	203.13	451.87	3.22
	Mustard	1.00	502.50	231.25	271.25	2.17
T_3	Lentil	0.618	502.13	209.38	292.75	2.39
	Grass pea	0.780	390.00	203.13	186.87	1.92
	Mustard	0.770	385.00	231.25	153.75	1.66

Input and out put price: Mustard seed = 1.25 \$ kg^{-1}, Lentil seed = 1.25 \$ kg^{-1}, Grass pea seed = 1.125 \$ kg^{-1}, Urea=0.25 \$ kg^{-1}, TSP= 0.275 \$ kg^{-1}, MP= 0.1875 \$ kg^{-1}, Gypsum=0.075 \$ kg^{-1}, $ZnSO_4$= 1.625 \$ kg^{-1}, Boric acid=1.625 \$ kg^{-1}, Mustard = 0.5 \$ kg^{-1}, Lentil = 0.8125 \$ kg^{-1}, Grass pea=0.5 \$ kg^{-1}

CONCLUSION

Relay crop with T. Aman rice like North-western parts of Bangladesh is a good option for marginal benefit. Relay lentil is best among others as because of more gross margin and serious labor crisis in this region. Marginal farmer's will be benefited more in this system of lentil cultivation. From the experiment it is revealed that treatment T_1 (15 day before harvest of T.Aman rice) was optimum for maximizing the yield as well as economically profitable and viable for relay crops lentil with T.Aman is superior to the other treatments in High Barind Tract soil.

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Effect of Different Bunch Coverings on Yield and Quality Of Banana (*Musa paradiasica* L.)Var. Grand Naine in West Bengal

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The experiment was carried out on Banana (L.) cv. "Grand Naine" at Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal .with the objectives to observe the effect of different bunch covering materials to increase economical yield and quality. The experiment was laidout in Randomized Complete Block Design with 3 replications. A set of treatments consisting of 10 treatments such as (T_1) Perforated polyethylene bag (PPB), early covering, (T_2) PPB, semi-early covering, (T_3) PPB, normal covering, (T_4) Gunny bag (GB), early covering, (T_5) GB, semi-early covering, (T_6) GB, normal covering, (T_7) Netted nylon bag (NNB), early covering, (T_8) NNB, semi-early covering, (T_9) NNB, normal covering, (T_{10}) No covering (control) was applied to tagged bunches on a single plant. Other cultural practices i.e., irrigation, fertilizer application and pollination were applied uniformly to all experimental units. The result indicated that bunches which were covered with polythene bags at early stage of bunch development resulted in minimum (10.27%), maximum benefit ratio (1.69 %) over control.

Keywords: Grand Naine, polyethylene bunch covers, postharvest quality, Bunch development.

INTRODUCTION

Banana (*Musa paradisiaca*) of family Musaceae is one of the most important fruit crops in the world(Samson, 1980) as it is available throughout the year, relatively inexpensive and is within the reach of all classes of buyers (Saravanan *et al*., 2012). Consumers use visual quality to purchase fresh produce fruits usually that is blemish-free (Shewfelt, 1999; Shewfelt, 2009). The supply of blemish-free fruit is difficult due to various types of mechanical injury and insect damage imparted on the delicate peel surface during growth and development, with wind and insects being the principal agents of this damage (Shanmugasundaran and Manavalan, 2002). Bunch covers provide protection to the fruit surface against pathogens, wind damage, leaf and petiole scarring, dust, light hail, sunburn, bird feeding, and handling damage during harvest and transport. A significant reduction in peel surface damage from insect pests may be obtained by covering the plantain or banana bunch shortly after pollination. In addition, the incidence of postharvest anthracnose disease has been shown to be significantly less on fruit from sleeved bunches. The net effect of bunch cover use is better fruit quality and increased marketable yield. Bunch covers of various materials and conditions have been extensively used in banana growing countries with the aim of improving yield and quality (Stover and Simmonds, 1987). Improved quality includes appealing skin color, reduced sunburn, reduced fruit splitting, and increasedfinger length and bunch weight among others (Robinson, 1996; Amarante, 2002). Bunch

covers have also been used to protect bunches from low temperatures, especially in temperate countries (Gowen, 1995; Robinson, 1996). This is due to enhanced physiological and metabolic activities provided by the microclimate created by bagging (Johns and Scott, 1989a). The objective of this study therefore was to investigate the effect of bunch covering on yield and postharvest quality of tissue cultured banana fruits using cv. Grand Naine as the test variety.

MATERIALS AND METHODS

The experiment was conducted for two banana crop season from June 2012 to August 2014 on "Grand Naine" banana variety in Experimental Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal. The plants were of uniform in size, growth and vigour which were provided with normal schedule of cultural practices i.e., irrigation, fertilizer application during two consecutive seasons. Bunch covering was done at three different stages of bunch development Normal bagging was done when all the hands have emerged; early bagging when the bud has started to curve downward but before the bract has lifted to expose the first hand and semi-early bagging after 2-3 hands have been exposed (Stover and Simmonds, 1987). Total number of treatments (10 treatments) such as (T_1) Perforated polyethylene bag (PPB), early covering, (T_2) PPB, semi-early covering, (T_3) PPB, normal covering, (T_4) Gunny bag (GB), early covering, (T_5) GB, semi-early covering, (T_6) GB, normal covering, (T_7) Netted nylon bag (NNB), early covering, (T_8) NNB, semi-early covering, (T_9) NNB, normal covering, (T_{10}) No covering (control) replicating the experiment with 3 replications in accordance with Completely Randomized Block Design. The data were statistically analysed using Analysis of Variance given by Gomez and Gomez (1984) employing the Indostat (Version-7.1) software package.

RESULTS AND DISCUSSION

Hand weight of Grand Naine banana was significantly influenced by the pre-harvest covering adopted during different stages of bunch development in both the plant and ratoon crop.

Covering the bunches with perforated polyethylene bags, gunny bags and netted nylon bags during early, semi-early and normal stages of bunch development in plant and ratoon crop (2.66-3.98 kg and 2.52-3.34 kg, respectively) increased the hand weight as compared with weight of the hands (2.43 and 2.29 kg, respectively) when bunches were left uncovered during bunch development but the difference was non-significant only with all the treatments of netted nylon bag in both the crop and also with gunny bag covering done at normal stage. Similar significant increase in fruit weight with bunch covering of perforated polythene bag was also reported by Patak and Mitra (2014). Covering the bunches of plant and ratoon crop during early stages of bunch development with perforated polyethylene bags though had highest hand weight but was statistically at par with perforated polyethylene covering done at semi-early and normal stage in plant crop while in ratoon crop bunch covering done at its semi-early and normal stage with perforated polyethylene cover and also with gunny bag covering done at early and semi-early stage, the difference was non-significant. This treatment on an average increased the hand weight over that recorded with no covering in both the crop was by 63.79 and 45.85 % while over 12.11-53.08 % and 2.45-32.54 % with other bunch coverings, respectively.

Early application of open bunch covers during its early development increased finger physical parameters thereby increasing its weight which ultimately was realized as increased bunch weight and yield as was also reported by Hasan *et al*. (2001). This effect suggests sensitivity to the environment during and soon after bunch emergence (Daniells *et al.,* 1992). This increase was comparatively higher with perforated polyethylene bags than gunny bags or netted nylon bags. Using perforated transparent polyethylene bags might have improved the micro-climate inside the bags which otherwise was not in case of gunny bags and netted nylon bags. Relative humidity and temperatures within the microclimate of the polythene bags are increased during daytime (Robinson and Nel, 1982). Increased temperature inside the cover accelerates banana fruit growth speed (Hasan *et al*., 2001).

The effect of pre-harvest bunch covering treatments on pulp and peel weight and pulp/peel ratio of Grand Naine banana was differently

influenced as is evidenced from Table 1. The portion of metabolites/photosynthates translocated to pulp (100.43-113.53 g and 100.33 112.33 g, respectively) and peel (37.07-42.74 g and 33.39-37.45 g, respectively) of the Grand Naine banana fruit in both the crops was generally more due to influence of pre-harvest bunch covering than those of fruits when their bunches were not covered (93.70 & 93.33 g and 36.37 34.74 g, respectively) except for peel weight in ratoon crop recorded with perforated polyethylene covering at semi-early stage and gunny bag covering at early stage where the peel weight recorded was lesser than the control i.e. no covering. However, the pulp and peel weight recorded was heaviest with perforated polyethylene bunch covering done at early stage of bunch development but was significant in case of pulp weight mainly except for netted nylon bags while in case of peel weight it was statistically at par with all the covering treatments in both the crops.

Table 1. Effect of pre-harvest bunch covering on TSS, hand, pulp and peel weight and pulp to peel ratio of Grand Naine banana

Treatment	TSS		Productivity		Hand weight		Pulp weight		Peel weight		Pulp to peel ratio	
	PC	RC	PC	RC	PC	RC	PC	RC	PC	RC	PC	RC
PPB + EC	22.9	22.9	68.87	66.88	3.98	3.34	113.5	112.3	42.6	37.4	2.7	3.2
PPB + SEC	22.6	22.7	68.27	65.83	3.55	3.26	111.7	111.7	41.6	33.4	2.7	3.4
PPB + NC	22.5	22.7	66.77	65.15	3.53	3.03	110.2	110.1	42.7	36.4	2.6	3.0
GB + EC	22.4	22.5	64.80	63.55	3.11	2.87	107.8	108.5	41.5	33.7	2.6	3.2
GB + SEC	22.6	22.3	64.42	63.23	3.19	2.84	105.8	105.8	41.2	36.4	2.6	3.4
GB + NC	21.1	22.2	63.40	61.91	3.01	2.78	105.0	105.5	42.1	36.1	2.5	3.0
NNB + EC	21.7	22.3	57.70	54.91	2.72	2.81	106.8	102.3	40.0	36.7	2.7	2.8
NNB+ SEC	21.6	22.6	57.95	56.16	2.66	2.60	103.1	106.3	39.9	34.8	2.6	3.1
NNB + NC	21.4	21.8	55.58	52.20	2.60	2.52	100.4	100.3	37.1	36.6	2.7	2.7
Control	20.5	20.8	43.20	41.70	2.43	2.29	93.7	93.3	36.4	34.7	2.6	2.7
CD (P = 0.05)	0.3	0.3	4.37	2.73	0.46	0.52	8.2	7.4	NS	NS	NS	NS

PC- plant crop; **RC-** ratoon crop; **PPB**- perforated polyethylene bag; **GB-** gunny bag; **NNB-** netted nylon bag; **EC-** early covering; **SEC-** semi-early covering; **NC-** normal covering

Consequent of the bunch covering, the translocation of metabolites to the edible portion of the fruit as compared to no covering treatment was non-significant in both the crops (2.52-2.75 and 2.70-3.45, respectively) i.e. pre-harvest bunch covering of has no influence on partitioning of metabolites to either pulp or peel. The highest pulp to peel ratio in plant crop was estimated with perforated polyethylene covering done at early stage and least with gunny bag covering done at normal stage while in ratoon crop highest ratio was estimated with perforated polyethylene bags at semi-early stage and least with no covering. Muchui (2012) also reported that bunch covering had no significant effect on changes in the pulp/peel ratio. This agrees with the result of the bunch weights below (section 4.2.1.6.) indicating that bunch covers increased bunch weights and especially the pulp portion giving the higher values for cultivar Grand Nain at harvest. In bananas, the pulp portion continues to grow even in the later stages of maturation (Turner, 1997).

TSS (21.37-22.88 & 21.80-22.90 °Brix, respectively) and starch (15.69-16.64 & 15.79-16.51%, respectively) content of the Grand Naine fruit in both plant and ratoon crop (Table 1) was significantly influenced by the pre-harvest bunch covering done at its different development stage as is evidenced from the significantly lower TSS and starch content of the uncovered control fruits (20.46 & 20.78 °Brix and 15.36 & 15.53%, respectively).

The best pre-harvest covering in terms of TSS in both the crop was perforated polyethylene bags at early stage (22.88 and 22.90 °Brix, respectively) and it was statistically at par with only perforated polyethylene bag and gunny bag covering done at semi-early stage in plant crop while in ratoon crop the treatment was statistically at par with perforated polyethylene bag covering done at semi-early and normal stage. Starch content of the fruits estimated highest with netted nylon bag covering at semi-early stage in plant crop followed by perforated

polyethylene bag covering at early and normal stage but the difference amongst them was non-significant. In ratoon crop, starch content was however estimated maximum with perforated polyethylene bag covering at early stage and was statistically at par with only perforated polyethylene bag covering at semi-early and normal stage.

The productivity of plant (55.58-68.87 t ha^{-1}) and ratoon (52.2-66.88 t ha^{-1}) crop banana cv. Grand Naine significantly increased with pre-harvest bunch covering over uncovered control (Table 1). The productivity obtained with uncovered control was only 43.2 and 41.7 t ha^{-1}, respectively. The quantum of increase in productivity with these pre-harvest bunch covering was in the range of 28.66-59.42 % in plant crop while in ratoon crop it was 25.18-60.38 % which is due to significant increase of yield parameters also with these pre-harvest bunch covering discussed earlier. The highest productivity of both the crops (68.87 and 66.88 83 tha^{-1}, respectively) was obtained with pre-harvest bunch covering of perforated polyethylene bag done at its early development stage. However, this productivity was though highest but statistically at par with the productivity obtained with perforated polyethylene bag done at semi-early (68.27 and 65.83 t ha^{-1}, respectively) and normal (66.77 and 65.15 t ha-1, respectively) stage in plant and ratoon crop and also with gunny bagging at early stage in plant crop (64.80 t ha^{-1}).

Moreover, the best pre-harvest bunch covering in terms of productivity in plant and ratoon crop was perforated polyethylene bags (66.77-68.87 and 65.15-66.88 t ha^{-1}, respectively) followed by gunny bagging (63.40-64.80 and 61.91-63.55 t ha^{-1}, respectively) and least productive was with netted nylon bagging (55.58-57.95 and 52.20-56.16 t ha^{-1}, respectively) and difference between them are significant. Significant increase in yield with of perforated polythene bunch covering of 0.5 mm thicknesses was also reported by Pathak and Mitra (2014) and so was recommended as suitable bunch covers (Stover and Simmonds, 1987). Moreover, pre-harvest bunch covering at the three different bunch development stages had no significant influence on productivity except in ratoon crop with netted nylon bagging between normal and semi-early stage. This indicates that to obtain better yield with better quality with extended shelf life of Grand Naine banana in Terai zone of West Bengal, a pre-harvest bunch covering of perforated polyethylene bag done at early stage of bunch development is recommended.

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Study the Effect of Boron, Molybdenum and Zinc and Their Combined Treatments on Growth and Yield Parameters of Broccoli in Terai Agro-Ecological Region of West Bengal

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Broccoli (*Brassica oleracea* L.) is one of the main cole crops of Brassicaceae or cruciferae family. The climate of Terai region of West Bengal is highly favourable for broccoli cultivation that argued for the possibility of getting more net profit of the farmers from cultivation of this high valued crop. But due to the micronutrient deficiency in the soil of terai region broccoli not gives good return for this reason the experiment was done. The present experiment was carried out to examine the effect of boron, zinc and molybdenum on broccoli (cv-green magic) with sole doses of these three micronutrients were fixed 0.3% for borax , 0.5% and 1.0% zinc sulphate as per and 0.03% and 0.05% per ammonium molybdate solutions as sole as well as their combined treatments on the yield and growth parameters of the broccoli. Among the sole treatments, application of zinc showed significantly higher effect on leaves per plants, leaf area, total chlorophyll content of the leaf and ascorbic acid content in the head. Significantly higher plant height showed by the treatments 0.03% Mo+1%Zn (59.10cm) and 0.05% Mo + 1% Zn (59.05cm), respectively. Irrespective of the treatments Zn had significantly positive influence in increasing the number of leaves per plant, especially at 0.5% dose. Significantly highest ascorbic acid was recorded at i.e., 61.54mg/ 100g of fresh head weight. Whereas, significantly highest leaf area were recorded at combination treatment of 0.3%, 0.03% Mo and 0.5% Zn (454.35 cm^2) and sole treatment of 0.5% Zn (452.33 cm^2).Combination of 0.3% borax, 0.03% ammonium molybdate and 0.5% zinc sulphate were recorded to be best for most of the traits.

Keyword: boron, zinc, molybdenum and broccoli.

INTRODUCTION

Broccoli (*Brassica oleracea* L.) is one of the main cole crops of Brassicaceae or cruciferae family. It is supposed to be the first of the Cole crops evolved from the wild species of cabbage or kale (Rubatzky and Yamaguchi, 1997). It is very popular for its tender knob and processed products like soup, vegetable curry preparation and others. Other than this it is a rich source of vitamin C, E, B1, carotenoids, phenolic (Lemoine *et al*., 2010; Goncalves *et al*., 2011; Parente et al., 2013) and possess anticancer properties due to presence of high amount of indole-3-carbinol (Solunke *et al*., 2011). Although it is a newly introduced crop in India but its demand is increasing rapidly with the increasing health conciseness among the consumers. The climate of Terai region of West Bengal is highly favourable for broccoli cultivation that argued for the possibility of getting more net profit of the farmers from cultivation of this high valued crop. But, major problem in this particular region is high level of soil acidity (Pati and Mukhopadhyay, 2011) that leads to greater extent of micronutrient deficiency viz., boron and molybdenum (Lal, 1993). This complex situation is ultimately becoming the major obstacle in full exploitation of the economical traits which

aggravating the return than the expected. Keeping all this information in purview the present experiment was designed to study the effect of boron, molybdenum, zinc and their different combinations on the growth and yield parameters of broccoli as well as to optimise sole and combined doses of micronutrients for better exploitation of the economic traits.

MATERIAL AND METHODS

The field experiments were carried out at Horticultural Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, situated at 26º 40' N latitude and 89º 38' E longitudes with average altitude of 43 m above the mean sea level (MSL) and soil pH 5.5-6.5 during autumn-winter season. In this experiment three important micronutrients *viz.,* boron, molybdenum and zinc along with their combinations were applied through foliar spray at 30 and 45 days after transplanting on locally popular cultivar "Green Magic" of broccoli. Rapid uptake of nutrients applied to crop foliage ensures a fast response within the plant as micronutrients directly enter the metabolic processes. Foliar applications of micronutrients are most completely available to the plant, because they are not either fixed or diluted in some large volumes of soil (Baloch et al., 2008). The sole doses of these three micronutrients were fixed 0.3% for borax as per Saha *et. al.(*2010), 0.5% and 1.0% zinc sulphate as per Lashkari *et al. (*2007) and 0.03% and 0.05% per ammonium molybdate solutions as per Saha *et al. (*2010) and their different treatment combinations. Thus three sole treatments as well as fourteen different combinations along with their control were laid out in randomized block design with 3 replications with a spacing of 45 x 45 cm in plot sized of 2.5 m x 2 m. Common cultural practices were used for the broccoli production such as irrigation, fertilization etc., according to recommended practices for broccoli in the commercial fields along with basal recommended dose of N, P_2O_5, K_2O (120 kg, 60 kg andm60 kg/ha, respectively) were followed. Observations were recorded on ten randomly selected plants from each plot. Data were recorded on five morphological traits viz. plant height (cm), leaves per plant, days to head maturity, head weight (g) and leaf area along with two bio-chemical traits viz. total chlorophyll content of leaf (mg/ 100g) and ascorbic acid of head (mg/g). Total chlorophyll content was estimated as per Sadasivam and Manickam (1996) and ascorbic acid was estimated as per AOAC (1990). Collected data were analysed statistically by using SPSS 22.0.

RESULT AND DISCUSSION

Data obtained from the field clearly indicated that there were significant effect of the micro-nutrients as sole as well as their combined treatments on the yield and growth parameters of the broccoli which justified the application of micronutrients at optimum level along with the macronutrients to promote better growth and yield in this region to fetch higher net return by the farmers. These phenomena might be due to beneficial effects of applying foliar plant nutrients particularly nitrogen, zinc, boron, iron and manganese and its sources play a key role in improving the productivity and quality of crop due their involvement in various enzymes and other physiologically active molecule (Alloway and Brain, 2008). Lahijie (2012) and Khosa *et al*. (2011) were reported that micronutrients play vital roles in the growth and development of plants, due to their stimulatory and catalytic effects on metabolic processes and ultimately on flower yield and quality.

Among the sole treatments, application of zinc showed significantly higher effect on leaves per plants, leaf area, total chlorophyll content of the leaf and ascorbic acid content in the head. Whereas sole application of boron was highly associated with head maturity. In our experiment we failed to trap any sole effect of molybdenum on mentioned parameters might be due to doses was not fitted well to express high level of physico-chemical responses that contradicted the earlier finding (Saha *et al*., 2010; Elkhatib and Chahal and Chahal).

However, sole as well as combined treatments of three micronutrients together depicted a very complex trend of effect. There was no huge significant variance throughout the treatments regarding the plant height. Significantly higher plant height showed by the treatments 0.03% Mo + 1% Zn (59.10 cm) and 0.05% Mo + 1% Zn (59.05cm), respectively. Irrespective of the treatments Zn had significantly positive influence in increasing the number of leaves per plant, especially at 0.5% dose. Other

than this the combined treatment of 0.3% B + 0.05% Mo + 0.5% Zn showed highly significant value (16.30) for this trait. Similar findings in case both of these two traits were reported by Kanti *et al*. (2013) in cauliflower.

Table: Different quantitative characters of plant along with treatment effects

Treatment	Plant Height (cm)	Leaves/ Plant	Days to Head Maturity	Head Weight (g)	Total Chlorophyll of Leaf (mg/100g)	Ascorbic Acid (mg/100g)	Leaf Area (cm^2)
$B_0M_0Zn_0$	57.55 ab	13.85 fg	70.25 b-d	350.28 m	6.48 c	48.32 gh	312.82 i
$B_0M_0Z_{0.5}$	58.25 ab	16.15 a	70.25 b-d	502.15 e	9.88 a	58.18 b	452.33 a
$B_0M_0Z_{1.0}$	57.85 ab	15.25 cd	70.95 a-c	412.23 i	7.64 b	52.23 de	328.24 h
$B_0M_{0.03}Z_0$	58.10 ab	13.65 fg	69.05 de	352.71 m	6.17 c	46.17 h	298.91 j
$B0M0.03Z_{0.5}$	58.45 ab	16.25 a	71.05 ab	518.22 d	9.78 a	59.61 ab	412.12 c
B0M0.03Z1.0	59.10 a	14.85 de	69.35 c-e	401.72 j	7.84 b	55.23 c	345.87 g
B0M0.05Z0	57.95 ab	14.05 f	69.25 c-e	348.54 m	6.42 c	48.11 gh	317.61 i
B0M0.05Z0.5	56.25 b	16.15 a	69.15 de	485.95 f	10.11 a	58.85 b	444.57 b
B0M0.05Z1.0	59.05 a	15.65 bc	71.95 a	398.65 j	6.54 c	50.43 e-g	361.55 e
B0.3M0Z0	58.45 ab	13.55 g	64.40 i	372.65 l	6.55 c	50.27 e-g	329.73 h
B0.3M0Z0.5	58.37 ab	15.95 ab	64.55 hi	612.85 b	10.33 a	60.17 ab	412.34 c
B0.3M0Z1.0	58.25 ab	15.05 de	67.15 fg	442.13 g	8.11 b	52.72 de	317.89 i
B0.3M0.03Z0	57.65 ab	13.80 fg	68.15 ef	385.82 k	6.63 c	51.25 ef	331.92 h
B0.3M0.03Z0.5	57.90 ab	15.85 ab	65.05 hi	625.33 a	10.23 a	61.54 a	454.35 a
B0.3M0.03Z1.0	58.10 ab	14.95 de	66.24 gh	428.55 h	8.17 b	49.17 fg	332.86 h
B0.3M0.05Z0	58.35 ab	14.10 f	69.15 de	401.11 j	6.75 c	54.35 cd	298.21 j
B0.3M0.05Z0.5	57.15 ab	16.30 a	64.95 hi	602.82 c	10.44 a	59.47ab	399.89 d
B0.3M0.05Z1.0	57.40 ab	14.65 e	68.45 ef	431.92 h	7.93 b	55.25 c	351.54 f

Means followed by the same letters are not significant at 0.05 percent level according to Duncan's test.

Analysed data clearly indicated that boron predominately influenced the head maturity and significantly reduced days required to obtain marketable output. Significantly minimum days for head maturity i.e., 64.40 days were recorded at 0.3% sole treatment of borax. Similar result obtained in case of head maturity also i.e., 0.5% Zn was most effective in reduction the days for head maturity along with combination treatment of 0.3% B + 0.05% Mo + 0.5% Zn. A very complicated association between the different treatment combinations were recorded in case of head weight that suggested the complex combinations of nutritional effect in up and or down regulation of enzymatic activity influence the head size and weight. However, B0.3% B + 0.03 Mo + 0.5% Zn showed significantly highest value for head weight. This finding was supported by the earlier works in cauliflower (Choudhary and Mukherjee 1999), cabbage (Pagodina and Izergina 1965), sweet potato (El-Bacy *et al.,* 2010) and broccoli (Saha *et al.*, 2010). Obtained data on chlorophyll content of leaves clearly indicated the significantly positive effect of all these three micronutrients, especially 0.3% B, 0.05% Mo and 0.5% Zn as sole treatment or as their combinations. Significantly highest ascorbic acid was recorded at i.e., 61.54mg/ 100g of fresh head weight at 0.3% B + 0.03% Mo+ 0.5Zn. Both the findings in case of chlorophyll content of leaf and ascorbic acid content were supported by the findings of Thapa *et al*. (2016). Whereas, significantly highest leaf area were recorded at combination treatment of 0.3% B, 0.03% Mo and 0.5% Zn (454.35 cm^2) and sole treatment of 0.5% Zn (452.33 cm^2). Throughout the data dominance of zinc in determining the leaf are might be due to its association in synthesis of tryptophane, stimulate the leaf growth of plant by active physiological process and there by increased leaf area (Lashkari *et al*., 2007).

However, it may be concluded from the above discussion that sole treatment of 0.05% zinc sulphate and combination of 0.3% borax, 0.03% ammonium molybdate and 0.5% zinc sulphate were recorded to be best for most of the traits.

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Effect of Pre Harvest Treatments on Growth, Flowering, Yield and Vase Life of *Gerbera jamesonii* cv. Red Gem

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An experiment was conducted on gerbera plants where ten treatments consisting of Control, GA_3 (50,100, 150 ppm), MH (200, 250, 300 ppm) NAA (200, 250, 300 ppm) were replicated three times and given a single spray at 2 months after planting in pots. Results revealed that the best treatment with respect to growth and flowering was with GA_3 100 ppm. While GA_3 100 and 150 ppm were proved to be the best in yield attributes and MH 250 ppm proved to be significantly better in influencing the vase life of cut gerbera flowers as compared to the various treatments under study.

Keywords: Gerbera, gibberellic acid (GA_3), maleic hydrazide (MH), naphthalene acetic acid (NAA).

INTRODUCTION

Gerbera (*Gerbera jamesonii*) is an important cut flower having good demand both in the domestic and international markets. The flower occupies the 5th position among the most important cut flowers of the global floriculture market. The rate of demand in ornamental products such as cut flowers and potted plants has gained a great momentum which has far surpassed the rate of supply. The growth and yield of plants is mainly influenced by two principle factors viz., genetic and cultivation or management factors. In recent years scientist have given due attention to the idea of regulating plant growth as third most important factor in improving the growth, yield and flower quality with the application of plant growth regulators in various ways. Growth regulators are known to have significant effect even in very small quantities and have been used in several ornamental crops. These substances modify the plant physiological processes within the plant, which ultimately affects plant growth and development. They are also expensive chemicals as such their optimum dose to get the targeted result needs to be standardized for the cultivation practice to be cost effective. Application of certain nutrients and growth regulators as foliar feeding has been found to improve growth and flowering of gerbera because high percentage of the nutrients is immediately absorbed by the leaves which influence the growth and development of plant and improve the quality of flower as well as increase the yield of cut flowers and suckers. Foliar application of growth chemicals also reduces the cost of production (Jamal Udin *et al*. 2011). However, the research work on this aspect of agro-technique in gerbera plants is lacking and so with a view to this, an investigation was carried out to study the effect of foliar application of plant growth regulators on growth, flowering, yield and vase life of *Gerbera jamesonii* cv. Red Gem.

MATERIALS AND METHODS

The experiment was conducted in the month of June-December in the year 2012 in the Experimental Farm of Horticulture Department in Nagaland University, School of Agricultural Sciences and Rural Development, Medziphema Nagaland. Plants of gerbera cv. Red Gem were pot cultured for the study. Ten treatments consisting of: T_0 - Control, T_1 - 50 ppm GA_3, T_2 - 100 ppm GA_3, T_3 - 150 ppm GA_3, T_4 - 200 ppm MH, T_5 - 250 ppm MH, T_6 - 300 ppm MH, T_7 -

200 ppm NAA, T_8 - 250 ppm NAA and T_9 – 300 ppm NAA were tested. The plants were given a single spray of the treatments at two months after planting. The experiment was carried out in a completely randomized design with three replications where each pot containing one number of suckers was taken as a unit. The pots were filled with a mixture of soil: sand: FYM in a 1:1:1 ratio and NPK @ 250:250:100 kg/ha was incorporated in the soil. Half dose of N and full dose of P and K were applied at the time of planting while the remaining half dose of N was applied at the time of flowering. The data pertaining to vegetative parameters, flowering attributes, yield attributes and vase life were recorded and analyzed statistically as per the method suggested by Panse and Sukhatme (1989).

RESULTS AND DISCUSSIONS

Effect on vegetative growth

It was evident from Table 1 that the various pre harvest treatments under study effected the vegetative growth of the plant significantly. GA_3 (150 ppm) resulted in greater number of leaves per plant while the highest value in terms of plant spread was recorded with GA_3 @ 100 ppm (34.33 cm). Application of GA_3 might have resulted in profuse cell division and cell elongation resulting in enhanced vegetative growth. This finding is in concurrence with the reports of Nair *et al*. (2002) and Dalal *et al.*, (2009). The increase in production of leaves with the application of gibberellic acid was a result of enhanced induction of leaf initial break *i.e.* differentiation of leaf primordial in the apical growing region (Dhaduk *et al*., 2007). The variation in plant height due to different treatments was found to be insignificant. However, the maximum plant height was recorded with NAA @ 200 ppm (26.33 cm). The increase in plant height as an influence of NAA application was also reported by Sooch *et al*. (2002). Leaf area was not significantly influenced by the different pre harvest treatments. However, the maximum leaf area was observed in MH @ 300 ppm (105.00 cm^2).

Table 1: Vegetative growth characters and days taken to bud emergence, bud burst and full bloom as influenced by pre harvest treatments

Treatments	Vegetative characters				Bud emergence (days)	Bud burst (days)	Full bloom (days)
	Number of leaves	Plant spread (cm)	Leaf area (cm^2)	Plant height (cm)			
T_0	70.67	32.00	98.67	23.33	125.67	137.33	147.00
T_1	68.33	30.67	103.67	23.50	125.00	136.33	145.00
T_2	67.33	34.33	97.33	24.33	125.33	136.00	144.33
T_3	77.33	32.67	90.33	24.00	124.33	134.00	141.00
T_4	61.00	30.33	89.00	22.17	126.33	137.00	148.67
T_5	67.00	30.33	92.00	23.67	126.67	137.00	148.33
T_6	60.67	32.17	105.00	22.00	126.67	138.00	151.67
T_7	40.00	33.83	85.67	26.33	128.67	139.67	152.67
T_8	57.00	31.67	90.67	24.33	127.00	138.67	147.67
T_9	36.67	33.00	96.33	26.00	130.67	143.00	158.67
CD at 5%	23.21	NS	NS	NS	NS	NS	7.78

Effect on flowering

A perusal of the data in Table 1 revealed that minimum number of days taken for bud emergence, bud burst and full bloom were recorded in GA_3 treatments. Among the GA_3 doses, 150 ppm significantly reduced the number of days taken to full bloom (141 days). These results corroborated with the findings of Dalal *et al. (*2009).

The data in Table 2 depicted that the maximum flower size was obtained in GA_3 @ 100 ppm (10.10 cm) which is statistically at par with GA_3 @ 50 ppm (9.87 cm). This is in conformity with the findings of Jadhao *et al*. (2010). The effect of various pre harvest treatments was non-

significant with respect to number of ray florets and disc florets. However, the maximum number was obtained in GA_3 @ 100 ppm (47.67) and (328.67) respectively. While the lowest number of disc floret (200.33) was recorded in NAA @ 250 ppm. GA_3 @ 100 ppm produced maximum diameter (7.07 cm) of disc floret but this result did not reach the level of significance. Increase in flower characters with GA_3 application may be attributed to active cell elongation in the flowers to increase the sink strength of the actively growing parts. Gibberillic acid has been reported to induce an entire developmental programme by activation of master regulatory genes in the later stages of corolla development (Weiss, 2000). Treatment with 300 ppm NAA registered maximum length of flower stalk (42.77 cm) which was statistically at par with 250 ppm NAA (42.23 cm) and 200 ppm NAA (41.67 cm). Stalk diameter did not vary significantly due to pre harvest treatments. However, 50 ppm GA_3 and 200 ppm NAA recorded the highest stalk diameter (0.63 cm). The highest neck diameter of 0.50 cm was obtained with the application of GA_3 @ 100 ppm, MH @ 300 ppm and NAA @ 200 ppm. GA_3 @ 100 ppm recorded the highest fresh weight (14.00 g) which was on par with NAA @ 200 and 300 ppm (13.67 g) whereas minimum fresh weight was recorded in control. The favorable effect of growth regulators might be due to cell elongation and rapid cell stimulation as has been reported by Singh (2004) in French marigold. The highest self-life was recorded in 250 ppm MH (19.33 days). Increased flower life with MH application might be due to retarded metabolism and respiration (Nair *et al.* 2002).

Effect on Yield

Out of the 10 treatments evaluated for their yield parameters (Table 3) the maximum number of flowers per plant was observed in GA_3 treatments followed by MH treatments. GA_3 @ 100 ppm gave a significantly higher number of flowers per plant (20.00) which is on par with GA_3 @ 150 ppm (19.67). The increase in yield and yield parameters with GA_3 spray may be due to better crop growth and more number of suckers thus increased the number of flowers per plant. Further, it can be ascribed due to better translocation of more metabolites from source to sink. Similar findings were reported by Nair *et al*. (2002) in Gerbera. The maximum number of suckers per pot was recorded with GA_3 @ 150 ppm (12.67). This might be due to the action of GA_3 in producing more number of leaves and after diversion of the photosynthates to the sink, the rest would have been used for the production of suckers. This is in close conformity with the findings of Nair *et al*. (2002).

Effect on vase life

Data in Table 3 showed that the vase life was profoundly influenced by the different pre harvest treatments where 250 ppm MH recorded the maximum vase life (14.33 days). The minimum vase life was recorded in control (9.00 days). Similar results were also obtained in the findings of Nouri *et al*. (2012). The reason for longer vase life in MH treated plants might be due to the action of MH in reducing the stomatal size and hence reducing the rate of respiration. Since the rate at which the rapid decline in water conduction of isolated stem segments was much reduced by MH, this might have resulted in better water balance within the plant (Nair *et al*. 2002).

From the above findings, it may be concluded that the best treatment with respect to growth and flowering was with GA_3 100 ppm. While GA_3 100 and 150 ppm were proved to be the best in yield attributes and MH 250 ppm proved to be significantly better in influencing the vase life of cut gerbera flowers as compared to the other treatments under study.

Table 3. Effect of pre harvest treatments on yield and vase life of Gerbera

Treatments	Yield parameters		Vase life (days)
	No. of flowers/ plant	No. of suckers/plant	
T_0	13.00	11.00	9.00
T_1	17.67	10.67	11.00
T_2	20.00	11.00	11.33
T_3	19.67	12.67	10.00
T_4	15.67	10.33	12.67
T_5	15.33	11.67	14.33
T_6	13.33	10.67	13.00
T_7	12.00	7.00	9.33
T_8	12.33	9.00	10.00
T_9	11.67	6.67	9.33
CD at 5%	6.17	3.70	3.19

Table 2. Floral attributes as affected by pre harvest treatments

Treatments	Fresh weight (g)	Flower size (cm)	Diameter of disc florets (cm)	Stalk length (cm)	Stalk diameter (cm)	Neck diameter (cm)	Number of ray florets	Number of disc florets	Self-life (days)
T_0	11.00	8.80	6.23	24.67	0.53	0.40	39.00	216.00	17.00
T_1	13.00	9.87	6.83	29.10	0.63	0.47	43.00	236.00	18.67
T_2	14.00	10.10	7.07	32.93	0.60	0.50	47.67	328.67	16.33
T_3	12.67	9.17	6.70	28.30	0.53	0.43	43.33	244.33	15.67
T_4	11.67	8.93	6.57	28.30	0.53	0.43	34.33	207.33	18.00
T_5	13.00	9.33	6.67	35.00	0.57	0.43	41.67	220.33	19.33
T_6	13.33	9.53	6.57	36.17	0.60	0.50	45.00	260.00	15.67
T_7	13.67	9.50	6.83	41.67	0.63	0.50	39.67	215.67	12.00
T_8	12.67	8.63	6.10	42.23	0.57	0.40	41.67	200.33	18.67
T_9	13.67	9.17	6.27	42.77	0.57	0.47	46.00	214.33	15.00
CD at 5%	1.98	1	NS	8.09	NS	0.08	NS	NS	4.51

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WINNER (Winter Nursery For Rice)- A Technology to Raise Winter Rice Nursery

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Very low temperature (~10 °C) prevails during winter in northern part of West Bengal. Due to this low temperature, growth of rice seedling gets stunted. Leaf bleaching also observed for susceptible genotype of rice. To avoid this problem a new nursery technique has been developed- WINNER. The seedling under WINNER method of nursery remained normal and was possible to achieve the transplantable size by 20 to 25 days. Whereas, in normal nursery (control) it took about 35 days to achieve transplantable size and it could achieve only during mid-February. The farmers of northern part of West Bengal or other places where low temperature prevails during *Boro*-rice nursery can raise nursery using WINNER method.

Keywords: Rice, winter nursery, low temperature

INTRODUCTION

Chilling injury occurs in many plants of tropical and subtropical origin when exposed to low non-freezing temperatures 10-15 °C (Saltveit and Morris, 1990). In Northern and North-eastern parts of India low temperature problem occurs in winter season usually during December to February the minimum temperature remains often below 15 °C. *Boro*-rice (summer rice), particularly seedling stage encountering critical low temperature is appeared to suffer from cold injury. The extent of cold injury depends on the nature and duration of low temperature and diurnal change of low temperature and diurnal change of low (night) and high (day) temperatures. There are three seasons of rice in West Bengal, viz., *Aus* (late winter), *Aman* (summer) and *Boro* (winter). The main season is the *Aman* for cultivation of rice in West Bengal, whereas the productivity is highest in *Boro* season. *Boro*-rice is cultivated during October/November to May/June. Cold tolerance at seedling stage is the primary requirement of *Boro* cultivars as seedlings are raised during the cold months of November and December. Water temperature during seedling establishment drops to about 10 °C and such low temperature significantly reduces seedling growth and establishment subsequently increased the length of vegetative period, particularly the seedling stage. The common symptoms of low temperature injury in rice are poor germination of seeds, poor establishment of seedling in the field and yellowing (leaf bleaching and tissue necrosis) of leaves. Leaf bleaching and tissue necrosis directly impair photosynthesis which reduced seedling growth. Synthesis of intracellular components, in particular of key proteins required for photosynthesis, is specifically susceptible to low temperature stress during development of rice leaves. The present technological intervention was to standardization and popularization of WINNER (Winter Rice Nursery) method of raising rice nursery.

MATERIALS AND METHODS

Nursery Preparation

The study material comprised of five rice genotypes from working collection of diverse origin. The experiment was conducted at

University Farm, UBKV, Pundibari, Cooch Behar, West Bengal using a randomized complete block design with four replications. Soil was ploughed to fine tilth under dry condition. In WINNER (Winter Nursery for Rice) nursery, beds of 1.20 m wide were made across the field. Seeds were soaked for overnight and sown on the beds. Seeds were covered with a mixture of soil and Farm Yard Manure or Vermi-compost (1 : 1 ratio). Watering with rose cane may be done depending on the soil moisture content. The beds are then covered with transparent polythene sheet (Fig. 1A). Watering with rose cane may be done once in a week depending on the soil moisture content. The beds may be left covered with polythene sheet till the main field ready for transplanting.

Data Recording

Observations were taken on low temperature tolerance ability (1-9 scale), seedling length, seedling fresh weight, seedling dry weight, days to 50% flowering and yield in kg per square meter. Data on seedling parameters were recorded on just two days before seedling uprooting for transplanting in main field (Table 1). The recording of cold tolerance was done following the Standard Evaluation System for Rice as out lined by International Rice Research Institute (IRRI, 2002). The scale for seedling cold tolerance ranged from 1-9 scale as- **score 1:** seedling dark green, **score 3:** seedling light green, **score 5:** seedling yellow, **score 7:** seedling brown/leaf bleaching (white), **score 9:** seedling dead. All the genotypes were rated for their response to low temperature tolerance on the basis of their colour and assigned scores accordingly. Low temperature tolerance scoring was not recorded for the *Kharif* crop as the seedlings were grown under normal temperature.

RESULT AND DISCUSSION

Nursery

In WINNER nursery, inside the polythene cover, the temperature was about 25 °C. Due to normal temperature inside the polythene cover, the seedlings grew normally. As the polythene sheets are transparent, photosynthesis will take place and the seedling remained green. But the seedlings bent sidewise due to polythene cover. However, the growth of seedlings remained normal in all respect without any chilling/cold injury (Fig. 1A). Before 2-3 days of uprooting the seedlings, the polythene covers were removed from the beds, the bended seedlings went upright position within 2-3 days which made ease in uprooting and transplanting of seedlings in the main field.

WINNER system of rice nursery during *Boro*-season is a unique method of raising seedling. In northern part of West Bengal, rice seedling nursery is prepared during fourth week of December to second week of January and seedlings are being transplanted during mid-February to first week of March. Generally the seedling age for transplanting is generally 35-45 days old seedling. Due to prevailing low temperature (~10 °C) during this period, the seedling remained stunted growth (Roy and Venkatasaralu, 2012) and sometime bleaching of seedling also observed (Fig. 1C,D,E). Thus, the seedling grown under normal practice takes more time to reach transplanting size. Following this WINNER nursery farmer can transplant their seedling in the main-field at the age of 25 days.

The seedlings of different genotypes in the control (normal nursery) beds showed different levels of low temperature sensitivity (Table 1, Fig. 1B,C,D,E). The variety- Annada was found to be moderately tolerant to low temperature at seedling stage. Variety MTU 1010 was found to be susceptible, whereas the varieties Pusa Basmati-1, UBKVR-1 and UBKVR-15 were highly susceptible to low temperature. The results corroborated with the findings Tiwari *et al*. (2009), Satya *et al*. (2010), Abdelkhalik *et al*. (2010), Roy and Venkatasaralu (2012).

Table 1. Classification of rice genotype based on tolerance against low temperature tolerance and comparing with the seedlings grown under WINNER

Score	Class	Genotype	
		Control	WINNER
1-2	Tolerant	-	Normal seedling growth was observed for all the genotypes
3-4	Moderately tolerant	Annada	
5-6	Susceptible	MTU 1010	
> 7	Highly susceptible	Pusa Basmati-1 UBKVR-1 UBKVR-15	

Seedling Parameters

Seedling length, seedling fresh weight and seedling dry weight showed much higher values under WINNER nursery as compared to traditional (control) nursery for all the genotypes of the rice (Table 2). The seedling height as affected by the low temperature during seedling stage directly influenced the seedling fresh and dry weights accordingly. High mortality of rice seedlings under low temperature condition is recurrent feature during *Boro*-season as compared to the *Kharif* season (Seema and Roy, 2007).

Table 2. Seedling parameters of 05 rice genotypes

Characters/Varieties	Situation	Genotypes					Mean
		Annada	MTU 1010	Pusa Basmati-1	UBKVR-15	UBKVR-1	
Seedling height (cm)	Control	6.81 b	5.92 b	6.99 b	6.73 b	7.68 b	6.83 b
	WINNER	22.30 a	21.90 a	24.25 a	23.51 a	25.98 a	23.59 a
Shoot fresh weight (mg)	Control	122.00 b	128.0 b	121.50 b	111.50 b	145.00 b	125.60 b
	WINNER	117.90 a	66.15 a	56.20 a	77.75 a	103.40 a	84.28 a
Shoot dry weight (mg)	Control	39.60 b	29.30 b	35.10 b	47.30 b	38.20 b	37.90 b
	WINNER	26.45 a	27.22 a	26.67 a	32.60 a	38.58 a	30.30 a

*Values bearing same letter in the column under each character are not significantly different at P=0.05 of LSD

Fig. 1. WINNER and normal puddled nursery for rice. A) WINNER duringduring *Boro*-rice; **B)** Stunted seedling without leaf bleaching when seedlings grown under puddled condition without polythene cover; **C)** Stunted seedling with moderate leaf bleaching when seedlings grown under puddled condition without polythene cover; **D&E)** Stunted seedling with severe leaf bleaching when seedlings grown under puddled condition without polythene cover.

Advantages of WINNER

1. Seedlings can be raised with limited water supply.
2. Preparation of WINNER nursery is easier than wet nursery.
3. There will be chilling/cold injury due to low temperature. Seedling grown under puddled condition without polythene cover will fetch chilling or cold injury which usually led in bleaching of leaves. In severe case leaves become complete white in colour (Fig. 12D&E). However, seedling of WINNER nursery will have normal growth.
4. The growth of the seedlings will be normal (Fig. 12A), whereas the stunted (Fig. 12B) is generally observed when seedling grown under puddled condition without polythene cover.
5. Pulling is easier. Seedlings come out easily and do not adhere to each other, so WINNER nursery facilitates single planting and quick manipulation during planting.
6. The labour fetches difficulties during transplanting of the seedlings grown under puddled condition without polythene cover. Due to normal growth of seedling under WINNER, transplanting is comparatively easier than the seedlings grown under puddled condition without polythene cover.

7. Establishment of the WINNER seedling in the main field is quicker as comparatively easier than the seedlings grown under puddled condition without polythene cover.
8. Seedlings raised in WINNER nursery tiller early and profusely.

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Determination of the Morphological and Physiological Aspects of the Flowers of Selected Sri Lankan Underutilized Blue Flower Species

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Sri Lankan biodiversity accounts for more than 800 endemic flowering plants, out of which, the most of the species are underutilized. In Sri Lanka, floriculture industry is limited to a few major crops and introductions from under-utilized plants would be an innovative approach to compete in world market. The objectives of this experiment were to determine the flower morphology of selected underutilized blue flowering plants from Matara District of Sri Lanka and the physiology of the flower in terms of pigment type and vacuolar pH to be used in breeding blue colour flowers. Following blue flower bearing genotypes were selected based on the abundance: *Commelina benghalensis*, *Clitoria ternatea*, an accession from family Boraginaceae (named as genotype "1"), an accession from family Convolvulaceae (named as genotype "2"), *Ipomoea pes-caprae,* and an accession from family Fabaceae named as *"Welmudumahana"* in *Sinhala* language. Morphological characters of the flower, flower pigment content and the vacuolar pH were determined. Five *Clitoria ternatea* genotypes of two in blue colour, two in white colour and one in a mixture of both blue and white were observed. Flowers of *Ipomoea pes-caprae*, genotype "1"and genotype "2" had five sepals and five petals. *Commelina benghalensis* is a flower with three petals and with three sepals including one reduced petal. A few flowers of *Commelina benghalensis* were converged to form a honey sack. In one *Clitoria ternatea* genotype, there were five petals and five sepals where one petal was larger and the other four were reduced petals. The other 4 genotypes of *Clitoria ternatea*, there were 3-5 large petals. The pigment extracts of all the flowers turned dark blue with 0.1M NaOH indicating that anthocyanin is present in the extract. The highest anthocyanin content of 5.4 and the highest pH of 5.9 were given by *Clitoria ternatea* blue colour flower with multiple petals and the genotype with a single blue petal gave a pH of 5.8 and OD of 5.08. In *Clitoria ternatea* the pH was around 4.7 and OD was zero. The genotype with white and blue colour, the pH was around 5 and the OD was 1.2. The anthocyanin content of the each flower was proportionate to the colour intensity of the petals. The vacuolar pH of 5.7 and OD of 3.75 was recorded from *Commelina benghalensis* and the accession "2". The genotype "1" also had a vacuolar pH of 5.4 and an OD of 3.15.The pH of 5.2 was given by *Ipomoea pes-caprae* and "*Welmudumahana"* which had petals of both blue and purple colours. It can be suggested that blue flowers contain delpinidin In the tested genotypes, intensity of blue colour was associated with comparatively high vacuolar pH. Studying the physiology of the flowers of these species with respect to flower colour would be useful in genetic engineering of crops for blue flowers. Further, consumer acceptance of above plants as potted plants should be tested in the future.

Keywords: Blue flower colour, Sri Lankan floriculture, underutilized flowering plants, vacuolar pH

INTRODUCTION

Sri Lanka owns rich plant diversity with 7000 indigenous flora, including 3156 flowering plants of which 894 are endemic to Sri Lanka (Dassanayake and Fosberg 1980; Wijesundara et al., 2012)). Around 6,800 species are native to Sri Lanka (Wijesundara et al., 2012). Among them most of the species are underutilized flowering plants. Floriculture in Sri Lanka is limited to anthurium, orchids, Gerbera etc. Therefore underutilized species should be explored for introductions of potted plants and cut flowers mainly.

Major pigment in flowers is anthocyanin. Anthocyanins are divided into cyanidins and their derivatives that produce colors ranging from red to purple (Griesbach, 1996); Pelargonidins and their derivatives that produce colors ranging from pinkish orange to orange (Iwata, et al., 1979); Delphinidins and their derivatives produce colors from blue to deep red (Asen and Siegelman, 1957). Delpinidin is responsible for blue colour through the expression of *F3'5'H* gene in anthocyanin biosynthesis pathway. A number of important ornamental plants, including anthurium, carnations, chrysanthemums, and roses lack blue flower colour genotypes due to absence of *F3'3'H* gene encoding delphinidin.

In Chrysanthemum, an induced *F3H* promoter with *F3'5'H* efficiently induced delphinidin production (Noda et al., 2013). Accumulation of delpinidin was achieved in white carnations as well, by expressing a *F3'5'H* gene and a petunia *DFR* gene (Tanaka, et al., 2009; Chandler and Tanaka, 2007; Tanaka, et al., 2010).

The adjusted vacuolar pH was reported to be affecting the flower colour in hydrangea, petunia, morning glory, orchids and roses in addition to pigment content (Asen and Siegelman, 1957., Yoshida, et al., 2003., Griesbach, 1996).

Five native blue flower colour species were selected in this study. *Commelina benghalensis* was detected in both abundant paddy fields and abundant wetlands. *Welmudumahana* was also detected in marginal lands. *Ipomoea pes-caprae* is a cover crop in plantations. *Clitoria ternatea*, Genotype "1" and Genotype "2" are found in home gardens. Genotypes were identified through taxonomic information. The objective of the study were to determine the morphological and physiological variation of selected genotypes. Our results will be useful as initial work on introduction of underutilized flowering plants and breeding for blue flower colour in Sri Lankan crops.

MATERIALS AND METHODS

Selection of Lants

Five blue colour flowering native plants were selected on abundance from Matara District, Southern Province, Sri Lanka in the agro ecological zone of WL2 where annual rainfall and temperature are 1900 mm and 28^{o}C respectively (Department of Agriculture, Sri Lanka, 2016).

Determination of the Taxonomy and Morphology of the Flower

Taxonomy was determined at family or species level based on flower morphology. The flowers with special flower modifications were recorded. Flower colour, number of petals, sepals and anthers were recorded. Position of the ovary was determined.

Confirmation of Purple Pigment as Anthocyanin (Uimari and Strommer 1998)

One gram of flower each genotype was weighed and from that 0.5 g was chopped and extract was taken in distilled water and 0.1M NaOH was added to the other 0.5g of water extract. Finally colors of the each accession were observed to prove the presence of anthocyanin.

The pH of Pigment Extract in Distilled Water as Assumed to Be Representing the Vacuolar pH

Five grams of petals from each genotype was chopped in 5ml of distilled water. The pH was measured in pigment extract in distilled water.

OD Value and the Anthocyanin Content of the Accessions

One gram from each accession were weighed and dipped in 5ml of Glacial Acetic Acid overnight to get the total anthocyanin in to the extract. Then Absorbance (OD value) at 525 nm of wave length using the spectrophotometer and the pH was measured. As the reference, pure Glacial Acetic Acid where Absorbance was zero and the pH was 2 and distilled water where Absorbance was zero and the pH was 7 were used.

RESULTS

Observation of the Taxonomy and Morphology of the flower

Ipomoea pes-caprae (*Muhudu Binthambaru*) and Genotype "2" are included in the family Convolvulaceae (Dassanayake, 1980). Flowers are borne singly or in small clusters. The corolla is round with five petals. Flower has five stamens and length of the filaments variable in the same flower. Ovary is superior. Genotype "2" flower characters were mostly similar to the *Evolvulus alsinoides* in tribe Cresseae: *Ipomoea pes-caprae* belongs to tribe ipomoeeae. This flower has five sepals, five fused petals, five stamens (stamens fused to the petals), and a superior ovary. There is a modified structure at base of peduncle making a sack contain a liquid, which is suspected to be nectar to facilitate cross pollination. *Commelina benghalensis is a flower with six t*epals, in two whorls of three each, the outer whorl green and the inner usually blue. The flowers have six stamens, in two whorls. Ovary is superior. *Clitoria ternatea* falls in to sub family faboideae with five sepals. Five irregular petals were of descending imbricate aestivation. One petal is large and covered the other small petals. There are ten stamens and nine are fused in genotype 3 and 7. The other genotypes from the five petals produced main large petals. "*Welmudumahana*" flowers had five small petals, five free stamens, five stamens. According to the morphological characters Genotype "2" was identified as a species in family Boraginaceae, where the flowers were similar to the genus *Brunnera* with five sepals, five petals, five stamens and with a superior ovary.

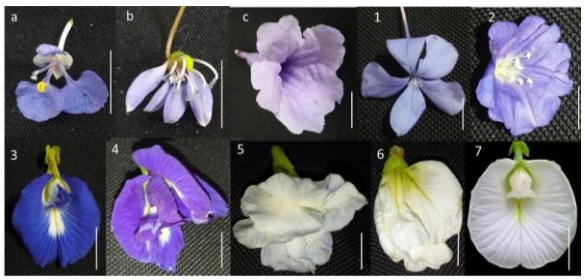

Fig. 1. Morphological diversity of selected natively grown blue colour flowers in Sri Lanka. (a) *Commelina benghalensis* (*Diya Meneriya*) from family Commelinaceae, (b) *Welmudumahana* from family Fabaceae (c)*Ipomoea pes-caprae* (*Muhudu Binthambaru*) from family Convolvulaceae, (1) Genotype "1" from family Boraginaceae (2) Genotype "2" from family Convolvulaceae (3), (4), (5), (6) and (7) *Clitoria ternatea (Katarolu)* from family Fabaceae

Figure 2. Flowers of *Commelina benghalensis* (The arrow indicates the honey sacks the petiole base)

Confirmation of purple pigment as anthocyanin (Uimari and Strommer 1998)

The pigment extracts of all the flowers turned dark blue with 0.1M NaOH indicating that anthocyanin is present in the extract according to Uimari and Strommer(1998) (Fig. 3). The similar observations were given for *Anthurium andraeanum* genotype "Red" proving the availability of anthocyanin.

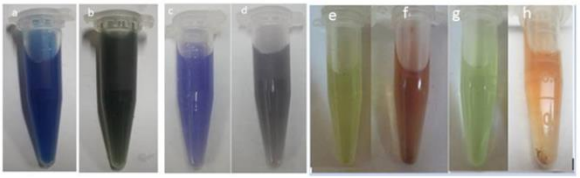

Fig. 3. Confirmation of purple pigment as anthocyanin (Uimari and Strommer 1998). (a)- Pigment extract in water of *Clitoria ternatea,* (b)- Pigment extract of *Clitoria ternatea* in water treated with 0.1M NaOH, (c)- Pigment extract of *Commelina benghalensis*, *Ipomoea pes-caprae* in water, (d)- Pigment extract of *Commelina benghalensis, Ipomoea pes-caprae* in water treated with 0.1M NaOH, e- *Anthurium andraeanum* genotype Red pigment extract in water treated with 0.1M NaOH, f- *Anthurium andraeanum* genotype Green pigment extract in water treated with 0.1M NaOH, g- *Anthurium andraeanum* genotype Red pigment extract in water, h- *Anthurium andraeanum* genotype Green pigment extract in water.

Anthocyanin content and Vacuolar pH of accessions

The highest anthocyanin content of 5.4 and the highest pH of 5.9 were given by *Clitoria ternatea* blue colour genotype with multiple petals and the genotype with single blue petal gave a pH of 5.8 and OD of 5.08. In *Clitoria ternatea* white genotypes the pH was around 4.7 and OD was zero and the hybrid genotype with both white and blue colour the pH was around 5 and the OD was

1.2. The anthocyanin content of the each flower was proportionate to the color intensity of the petals. The vacuolar pH of 5.7 and OD of 3.75 was given by *Commelina benghalensis* and the genotype "2". The genotype "1" also had a vacuolar pH of 5.4 and an OD of 3.15. The pH of 5.2 was given by *Ipomoea pes-caprae* and "*Welmudumahara"* wherein petals both blue and purple colours were observed. *Clitoria ternatea, Commelina benghalensis* and genotype "2" should have the delpinidin and other three species with blue and purple colour mix may have both delpinidin and cyanidin. Delpinidin is considered as the anthocyanidin that causes blue colour in flowers. Cyanidin is considered as the anthocyanidin that causes purple colour. It can be suggested that *Clitoria ternatea and Commelina benghalensis* should have higher levels of delpinidin. There are reports on changing flower colour in to blue in a higher vacuolar pH. Although the sepals of hydrangea have only one anthocyanin named delphinidin- 3-glucoside, the color displayed varies from red to blue (Asen and Siegelman, 1957) with corresponding changes in vascular pH from 3.3 to 4.1 (Yoshida *et al*., 2003). The attempts to generate blue roses through the introduction of the flavonoid 3',5 '-hydroxylase (*F3'5'H*) gene were unsuccessful due to improper pH. Katsumoto et al., (2007) generated blue roses by placing the *F3'5'H* gene into a genetic background with higher vacuolar pH and high flavonol content. Therefore, the relationship between the blue colour in tested flowers and vacuolar pH can be suggested. Further investigations on physiology of the flowers of these species in terms of flower colour would be useful in genetic engineering of the local flowers for blue colour.

Table 1. Anthocyanin contents, optical density values and vacuolar pH of the tested flower genotypes

Species	Anthocyanin Content(OD/g)	Vacuolar pH
Ipomoea pes-caprae	3.05	5.2
Genotype "1" in family Boraginaceae	3.15	5.4
Commelina benghalensis	3.75	5.7
Welmudumahara	2.94	5.2
Genotype "2" in family Convolvulaceae	3.78	5.7
Clitoria ternatea genotype " 3"	5.08	5.8
Clitoria ternatea genotype " 4"	5.12	5.8
Clitoria ternatea genotype " 5"	1.2	5.0
Clitoria ternatea genotype "6"	0.0	4.7
Clitoria ternatea genotype "7"	0.0	4.7

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Dwarf Genotype of Rice (*Oryza sativa* L.)- A Prospective Medium Duration Rice

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UBKVR-36, a dwarf-genotype developed from cross between MTU7029 and Annada at Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal. It is suitable for medium land situation. It is highly resistant to lodging, non-shattering in the field, dwarf (67.20 cm), days to 50% flowering during *Boro*-season is 134.30. It is moderately resistant to leaf blast, neck blast, brown spot, sheath rot and leaf folder. Its average yield is 6.3 t/ha in the research plot. Grain type is short bold. It has been already accepted in adopted villages of UBKV, namely Singhimari, Petlanepra and Unishbisha. In the present communication, the characteristics of a new dwarf genotype of rice– UBKVR-36 were studied in detail using morphologically.

Introduction

Rice is an ancient crop, its cultivation dating back more than 4000 years. It is staple food for Asian and African peoples. It is gaining importance in Latin America and gradually spreading its area of cultivation in North America. The yield potential of rice has been greatly increased by the so-called rice 'green revolution', which is represented by rice dwarf breeding (Hargrove and Cabanilla, 1979; Khush, 1999). Finding of new genes for rice plant height and research its genetic mechanisms is still a research focus in rice genetics and genomics.

When modern methods of rice production are applied to tropical rice, results are discouraging. Use of adequate fertilizer-especially nitrogen and adoption of good weed, insect, and water control practices cause these tropical rice varieties to grow excessively tall, to produce extra-long, drooping leaves, and to lodge or fall over. Thus, the plant height is one of the most important agronomic traits of rice (*Oryza sativa* L.) for development of lodging tolerance. In the present communication, the characteristics of a new dwarf genotype of rice– UBKVR-36 were studied in detail using morphologically.

Materials and Methods

Parents of UBKVR-36 were MTU 7029 and Annada. MTU 7029 was developed at Maruteru, Andhra Pradesh and notified in 1987 (Rice Knowledge Management Portal, dated 12th September, 2016). It is long duration (140-150 days), semi-dwarf rice variety with short bold grain, and yield potential (6.5 t/ha) in low input response areas, it is resistant to BLB, but susceptible to leaf blast, sheath blight and gal-midge. Annada is semi-dwarf short duration rice tolerant to drought. Grains of Annada are bold and having high yield potential.

The parents and UBKVR-36 were grown side by side for comparison during *Kharif* season (2016 and 2017). For morphological characterization, the genotypes was cultivated along with four other advanced line (UBKVR-1, UBKVR-15, UBKVR-15A and UBKVR-67) keeping Nabin as check. The experiment was conducted at University Farm, UBKV, Pundibari, Cooch Behar, West Bengal using a randomized complete block design with two replications. UBKVR-36 had been characterized based on the "Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability

on Rice (*Oryza sativa* L.)" of PPV&FRA (2007).

Results and Discussion

Comparison of UBKVR-36 with its parents

UBKVR-36 was comp red with its parents during *Kharif* because one of the parent, namely MTU7029 is long duration rice and can be grown during *Kharif*-season only. UBKVR-36 took 109 days to attained 50% flowering during which is in between of the two parents MTU 7029 and Annada to the days to 50% flowering of Annada (Table 1). The most important is that the recordable reduction in plant height of UBKVR-36 as compared to the parents. It has yield potential about 6.10 t/ha, which is higher than both of the parents.

Table 1: Comparison of UBKVR-36 with its parents

Genotypes	Characters		
	MTU 7029	UBKVR -36	Annada
Days to 50% flowering	127.0	109.0	82.0
Plant heights (cm)	**116.2**	**66.3**	**89.7**
No. of tiller/plants	14.3	18.1	15.5
Grain yield/plant (t/ha)	5.70	6.10	5.10

Per se performance of UBKVR-36 during Boro-season

Days to 50% flowering of UBKVR-36 was 134.0 days. It took few days more to attain days to 50% flowering as compared to other advanced lines and the check variety- Nabin (Table 2). Plant height ranged from 67.2 to 103.4 cm. Panicle length ranged from 19.2 to 25.0 cm. UBKVR-36 was the shortest plant among the other genotypes in this study. However, it also showed smallest panicle. According to PPV&FRA guideline on rice (2007), it falls under very short category based on the stem length. Number of tillers per plant varied from 11.2 to 20.0. UBKVR-36 recorded maximum number of panicles per plant. UBKVR-36 has high yield potential (6.3 t/ha).

Plant height is an important character in relation to lodging. Generally dwarf and semi-dwarf genotypes are lodging tolerant (Shylaraj *et al*., 2006; Wei *et al*., 2013). UBKVR-36 was very short in plant height and it was found to be lodging tolerant. It is also have high yield potential. This advanced lines has be accepted by farmers of the adopted villages of the University, namely, Singhimari (Cooch Behar-II block), Petlanepra (Sitalkuchi block) and Unishbisha (Ghoskadanga-II block) of Cooch Behar district.

Table 2: *Per se* performance during *Boro*-season

Genotypes	Characters				
	Days to 50% flowering	Plant heights (cm)	Panicle length (cm)	No. of tiller/plants	Grain yield/plant
UBKVR-1	130.0	103.4	22.6	12.0	7.2
UBKVR-15	116.0	91.6	20.0	16.0	5.1
UBKVR-36	**134.0**	**67.2**	**19.2**	**20.0**	**6.3**
UBKVR-46	124.0	95.3	22.3	13.5	6.2
UBKVR-67	129.0	97.1	25.0	11.2	6.8
Nabin	118.0	99.0	24.4	14.6	6.4
Range	118.0-134.0	67.2-103.4	19.2-25.0	11.2-20.0	5.1-7.2

Note: Due to long winter, the seedlings under this agro-climate take about **25-30 days** more to attain transplanting size, so the total duration high as compared to normal duration

Characters of UBKVR-36 based on DUS guideline

UBKVR-36 had also been characterized based on the "Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability on Rice (*Oryza sativa* L.)" of PPV&FRA (2007). Thirty

three characters have been considered. Based on DUS characterization, UBKVR-36 is **very short** by stem length, semi-erect flag leaf, having medium leaf length, erect culm attitude, short panicle, droopy panicle curvature, complete panicle exertion, brown furrow on straw lemma and palea colour, no awn and it is non-aromatic (Table 3).

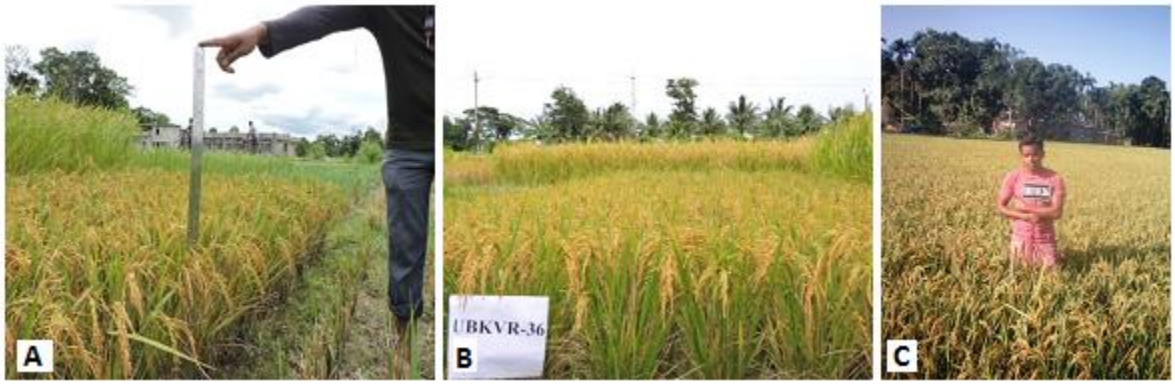

Fig. 1. Advance line- UBKVR-36. A&B) Crop in the field; **C)** Crop in the farmers' field

Table 3. Some morphological characters of UBKVR-36 based on the "Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability on Rice (*Oryza sativa* L.)" of PPV&FRA (2007)

Sl. No.	Characters	Classification
1.	Coleoptiles: Colour	Colourless
2.	Basal leaf: sheath colour	Green
3.	Leaf: Intensity of green colour	Dark
4.	Leaf: Anthocyanin colouration	Absent
5.	Leaf sheath: anthocyanin colouration	Absent
6.	Leaf: Pubescence of blade surface	Medium
7.	Leaf: Auricle	Present
8.	Leaf: Anthocynin colouration of auricle	Colourless
9.	Leaf: Collar	Present
10.	Leaf: Anthocyanin colouration of collar	Absent
11.	Leaf: Ligule	Present
12.	Leaf: Shape of ligule	Split
13.	Leaf: Colour of ligule	White
14.	Leaf: Length of blade	Medium
15.	Leaf: Width of blade	Medium
16.	Culm: attitude	Erect
17.	Flag leaf: Attitude of blade (early observation)	Semi-erect
18.	Lemma: Anthocyanin colouration of keel	Medium
19.	Lemma: Anthocyanin colouration of area below apex	Medium
20.	Lemma: Anthocyanin colouration of apex	Medium
21.	Spikelet: Colour of stigma	White
22.	Stem: Thickness	Medium
23.	**Stem length (excluding panicle)**	**Very short**
24.	Stem: Anthocyanin colouration of nodes	Absent
25.	Stem: Anthocyanin colouration of internodes	Absent
26.	Panicle: Length of main axis	Short
27.	Panicle: Curvature of main axis	Dropping
28.	Panicle: Number per plant	Medium
29.	Spikelet: Colour of tip of lemma	Brown
30.	Lemma and Palea: Colour	Brown furrow on straw
31.	Panicle: Awns	Absent
32.	Panicle: Exertion	Well exerted
33.	Decorticated grain: Aroma	Absent

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