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Full Length Research

Effect of chitosan application on plant characters, yield attributes and yield of mungbean

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A pot experiment was conducted at the pot yard of Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh during the period from March to May 2011 to investigate the effect of Chitosan application on morphological and biochemical characters, yield attributes and yield in mungbean. The experiment comprised five levels of Chitosan concentrations viz., 0 (control), 25, 50, 75 and 100 ppm and two recently released mungbean variety, BINAmung-7 and BINAmung-8. The experiment was laid out in a two factors completely randomized design with four replications. Chitosan was applied in two times at vegetative (30 days after sowing) and flower initiation stage (40 days after sowing). Application of Chitosan increased on morphological characters such as plant height, number of branches and leaves plant^{-1} and leaf area plant^{-1},total dry mass (TDM) production, biochemical parameters such as chlorophyll, nitrate reductase (NR) and photosynthesis in leaves, reproductive characters such as peduncle and scar number plant^{-1}, yield attributes and seed yield in mungbean, whereas reproductive efficiency and harvest index decreased in Chitosan application. From the research findings, results showed that most of the plant parameters increased with increasing concentration of Chitosan till 50 ppm followed by a plateau. The highest seed yield plant^{-1}(9.31 g) was recorded in 50 ppm Chitosan due to increased number of pods plant^{-1} and increased dry matter partitioning to economic yield. In contrast, the lowest seed yield plant^{-1} (7.28 g) was observed in control plants due to inferiority in yield attributes. Therefore, foliar application of Chitosan at the rate of 50 ppm spray at vegetative and reproductive stages may be used for getting increased seed yield in mungbean.

Key words: Chitosan application, mungbean, morphological characters, yield attributes and yield.

INTRODUCTION

Mungbean (*Vignaradiata L. Wilczek*) is one of the most important pulse crops of global economic importance. The cultivated mungbean belongs to the family Leguminosae, sub-family Papilionaceae. It is cultivatded most extensively in Bangaldesh, India, Pakistan, Myanmar, Srilanka, Thailand, China, Japan, Philippines, Vietnam, Korea and Indonesia. Mungbeans are also called mongo, moog and green bean. The English version mung comes from the Hindi moong. Bangladesh is a developing country and there is a serious nutritional problem in the cereal based diet for her common people. Pulses constitute the main source of protein for the people particularly the poor section of Bangladesh. It is considered as 'poor man's meat because it is an excellent source of vegetable protein. Among the pulses, mungbean ranks first position in price, second both in acreage and production and third in protein content in Bangladesh. In our country total production of mungbean 1.16 lac metric tons from the area of 1.42 lac hectare in (BBS 2009-10). The yield of mungbean 1.13 metric tons

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per hectare (BBS 2009-10).The principal constraint of mungbean production is its low yield potential (1070 kg ha^{-1}, BBS, 2009). From 70 to 95% of mungbean flowers do not develop into mature pods (Mondal, 2007) indicating that potential fruit or seed number is usually much larger than the number actually produced by the plant community. The yield performance under Bangladesh condition is lower compared to other mungbeangrowing countries (FAO, 2007). So, urgent need to increase yield in mung bean by proper management practices.

Plant growth regulators are one of the most important factors for increasing higher yield. Application of hormone has good management effect on growth and yield of field crops (Imam et al., 2010).In agriculture, chitosan is used primarily as a natural seed treatment and plant growth enhancer, and as an ecologically friendly biopesticide substance that boosts the innate ability of plants to defend themselves against fungal infections. The natural biocontrol active ingredients, chitin/chitosan, are found in the shells of crustaceans, such as lobsters, crabs, and shrimp, and many other organisms, including insects and fungi. It is one of the most abundant biodegradable materials in the world. Degraded molecules of chitin/chitosan exist in soil and water. Chitosan applications for plants and crops are regulated by the EPA. Chitosan increases photosynthesis, promotes and enhances plant growth, stimulates nutrient uptake, increases germination and sprouting, and boosts plant vigor. When used as seed treatment or seed coating on cotton, corn, seed potatoes, soybeans, sugar beets, tomatoes, wheat and many other seeds, it elicits an innate immunity response in developing roots which destroys parasitic cyst nematodes without harming beneficial nematodes and organisms. Agricultural applications of chitosan can reduce environmental stress due to drought and soil deficiencies, strengthen seed vitality, improve stand quality, increase yields, and reduce fruit decay of vegetables, fruits and citrus crops. Horticultural applications of chitosan increases blooms and extend the life of cut flowers and Christmas trees.The physiological mechanisms of mungbean growth are hormonally mediated. Plant growth regulators (PGRs) are being used as an aid to enhance yield (Nickell, 1982). Chitosan is a synthetic plant growth regulator which can manipulate a variety of growth and yield in various crops. The PGRs production in a small amount in the plant body is the most essential for the growth and development of the plants.

Additional supply of PGRs controls growth and yield in plants. Effect on growth, yield and yield attributes of various crops was studied by many workers using different PGRs but literature regarding the effect chitosan on mungbean is very scanty. Therefore, the present research work was carried out with different concentrations of chitosian to study the effect of chitosan on morphological features, growth, yield attributes and yield in mungbeanandto find out the optimum concentration of chitosan for higher production of mungbean.

MATERIALS AND METHODS

The experiment was carried out at the pot yard of Bangladesh Institute of Nuclear Agricultural (BINA) Mymensingh, during the period from March to May 2011. Geographical the experimental field located at 24°25 N" latitude and 90°50'N longitude at the elevation at 18 m above the sea level (FAO, 1988).The soil of the experiment was collected from BINA farm; Mymensingh. The collected soil belonging to the agro-ecological zone of Old Bahmaputra Floodplain (AEZ-9). The experimental field was under subtropical climates characterized by heavy rainfall during the month of April to September and scanty rainfall during October to March. Two mungbean varieties (BINAmung-7, BINAmung-8) were used in the present study. The seeds of the variety were collected from the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. The plant growth regulator Chitosan was collected from Radiation Chemistry Division, Bangladesh Atomic Energy Commission, Saver, Dhaka.The experiment consisted of two factors that is Factor A:two mungbean variety i) BINA mung-7 ii) BINA mung-8 and Factor B: Application of different doses of plant growth regulators (PGRs) Chitosan @ Control (0 ppm that is water sprayed), 25, 50, 75 and 100 ppm respectively. The two factor experiment was laid out in a Completely Randomized Design (CRD) with four replications.

Silty loam soils were collected from BINA farm, Mymensingh. The collected soil was well pulverized and dried in the sun. Plant propagules, inert materials, visible insects and pests were removed from this soil. The dry soil was thoroughly mixed with well rotten cow dung. This prepared medium was used in filling the pots after well mixing thoroughly with given amounts of urea, triple super phosphate and muriate of potash and gypsum at the rate of 0.70, 1.05, 0.60 and 0.80 g/pot corresponding to 40, 80, 60 and 40 kg/ha, respectively. Earthen pots of 25 cm diameter and 30 cm height were used for the experiment. The pots of the experiment were filled with 12 kg of soils.Three seeds were sown in each pot on 15 March 2011. Finally, they were thinned to one seedling after 20 days of sowing. The data recorded on different parameters under the experiment were statistically analyzed to obtain the level of significance using the MSTAT-C package program developed by Russell (1986). The differences between pairs of means were compared by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984). Water was supplied as and when needed to ensure sufficient moisture for the normal growth of the plants; first weeding was carried out at 25 DAS and second one was done at 60 DAS.All the plants of the pots were harvested at time on 30 may 2011, when most of the pods become mature (90% pods were mature) the mature pods were collected by hand and then sun dried and weighed.The formulation of Chitosan was water soluble powder. For preparation of Chitosan working solution 25, 50, 75 and 100 ppm of original powder were added separately to 1 L of water contained in volumetric flax and spraying was done onmungbean plants at afternoon by using a hand sprayer at 25 and 35 DAS: Water was supplied as and when needed to ensure sufficient moisture for the normal growth of the plants; first weeding was carried out at 25 DAS and second one was done at 60 DAS.All the plants of the pots were harvested at time on 30 may 2011, when most of the pods become mature (90% pods were mature) the mature pods were collected by hand and then sun dried and weighed. Crop sampling and data collection of morphological, physiological and biochemical parameters were done after harvesting. Leaf area per plant was measured by automatic leaf area meter (LICOR 3000, USA). Chlorophyll was estimate following the procedure of Yoshida et al. (1979). Chlorophyll content was estimated as follows:

$$\text{Total chlorophyll (mg g}^{-1}\text{fw)} = [20.2 \times A6_{45} - 8.02 \times A663] \times 0.2$$

NRase was estimated following the procedure of Stewart and Orebamjo (1979). Photosynthesis was measured of 3rd top most leaf at flowering and pod development stage by automatic photosynthesis meter (LICOR 1400, USA).The data recorded on different parameters under the experiment were statistically analyzed to obtain the level of significance using the MSTAT-C package program developed by Russell (1986). The differences between pairs of means were compared by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of foliar application of Chitosan

Application of Chitosan had a profound influence on morphological characters such as plant height, number of branches and leaves plant^{-1} and leaf area plant^{-1} in mungbean (Table 1). Results revealed that plant height, number of branches and leaves plant^{-1} and leaf area plant^{-1} were greater in Chitosan applied plants than control plants. Results showed that plant height, number of branches and leaves plant^{-1} and leaf area increased with increasing concentrations of Chitosan till 50 ppm followed by a pluatu. In contrast, the shortest plant, lowest number of branches and leaves plant^{-l}, and leaf area were observed in control plant. Results revealed that plant height increased with increasing concentration of Chitosan till 75 ppm followed by slightly declined. The highest plant height was recorded at 75 ppm of Chitosan (36.75 cm) followed by 100 ppm (35.80 cm) and 50 ppm (35.40 cm) with same statistical rank. In contrast, the shortest plant was recorded in control plant (31.10 cm). Similar result was also reported by Chibu et al. (2002a) in rice who reported that plant height increased in Chitosan applied plants as compared to control plants. The highest branches plant' was observed in 50 and 100 ppm Chitosan (2.65) followed by 75 ppm (2.57) with same statistical rank. In contrast, the lowest branches plant^{-1} was recorded in control plants (1.85 plant^{-1}). Similar result was also reported by Chibu et al. (2000) who reported that there was an increase in branch number for Chitosan application in soybean. The leaf production by 50 ppm Chitosan was significantly higher over other doses except 100 ppm and control had the lowest leaf production (14.63 plant^{-1}). The variation in leaf number might occur due to the variation in branches and plant height. The result obtained from the present study is consistent with result of Yue Dong et al. (2001) in maize who stated that leaf number increased with increasing concentration of Chitosan at certain level. The effect of different levels of Chitosan application on reproductive characters such as peduncle and scar number plant^{-1} and reproductive efficiency (RE) was significant (Table 2). Results showed that peduncle number plant^{-1} increased with increasing concentration of Chitosan till 50 ppm followed by a decline whereas scar number plant^{-1} increased with increasing concentration of Chitosan. On the other hand, RE decreased with increasing concentration of Chitosan. Therefore, the highest RE was recorded in control plant (26.14%) and the lowest was recorded in 100 ppm Chitosan (19.81 %).For yield attributes, results showed that pod number and 1000-seed weight increased with increasing concentration of Chitosan till 50 ppm followed by a decline.The highest number of pods plant^{-1} and 1000-seed weight were recorded in 50 ppm Chitosan. The lowest number of pods plant was recorded in control plants (20.42) whereas the lowest 1000-seed weight was observed in 1000-seed weight (36.80 g). Foliar application of Chitosan had no influence on pod length and number of seeds pod^{-1}.The highest seed yield was recorded in 50 ppm Chitosan (9.31 g plant^{-1}) due to increased pods plants. The lowest seed yield was recorded in control plants for fewer production of pods plant^{-1}. This result indicates that 50 ppm concentration of Chitosan. In case of biochemical parameters, results showed that chlorophyll, nitrate reductase (NR) and photosynthesis in leaves increased in Chitosan applied plants than control plants but within the Chitosan applied plants, there had no significant different in the above studied biochemical parameters.

Effect of variety

The effect of variety on morphological, physiological, biochemical, reproductive parameters, yield attributes and

Table 1. Effect of different levels of Chitosan and variety on some morphological and biochemical characters in mungbean.

Treatments Concentration (PPm)	Plant height (cm)	Branches plant^{-1} (no.)	Leaves plant^{-1} (no$^{\cdot}$)	Leaf area plant^{-1} (cm^2)	Chlorophyll (mg g^{-1}fw)	Nitrate reductase (µmol NO^{-2} /g fw)	Photosynthesis (µmol C0$_2$S^{-1}dm $^{-2}$)
0	31.10 c	1.85 c	14.63 d	1156 c	2.19b	3.84b	15.36b
25	34.35 b	2.25 b	16.00 c	1265 b	2.29ab	4.21a	16.71a
50	35.40 ab	2.65a	19.08 a	1355 a	2.35 a	4.30 a	17.29 a
75	36.75 a	2.57 a	17.50 b	1320 ab	2.35a	4.29a	17.25a
100	35.80 ab	2.65 a	18.60 a	1351 a	2.40a	4.33a	17.41a
F-test	**	**	**	**	*	**	*
LSD (0.05)	1.44	0.19	1.05	70.58	0.12	0.18	0.95
Variety							
BINA mung-7	39.76 a	3.65 a	23.09 a	1605 a	2.21 b	4.06 b	15.99 b
BINA mung-8	29.60 b	1.14 b	11.23 b	972 b	4.33a	4.33a	17.16a
F-test	**	**	**	**	**	**	**
LSD (0.05)	1.22	0.14	0.92	65.23	0.09	0.15	0.82
CV (%)	4.08	7.87	5.96	5.36	5.04	4.28	5.56

In a column figures having same letter (s) do not differ significantly at P < 0.05; ** indicates significant-at. 1% level of probability.

Table 2. Effect of foliar application of Chitosan and variety on some reproductive characters, yield attributes and seed yield of mungbean.

Treatments	Peduncles plant^{-1} (no.)	Scars plant^{-1} (no.)	Reproductive Efficiency (%)	Pods plant^{-1} (no.)	Pod length(cm)	Seeds pod^{-1} (no.)	1000-seed weight (g)	Seed yield plant^{-1} (g)
Concentration (ppm)								
0	10.75 c	78.78 d	26.14 a	20.42 c	7.62	10.80	37.26 b	7.28 d
25	13.23 b	88.50 c	26.10 a	23.25 b	7.87	11.21	37.87 a	8.70 b
50	14.59 a	102.3 b	25.03 ab	25.95 a	7.90	11.30	38.00 a	9.31 a
75	14.50 a	108.4 ab	23.07 b	24.15 b	7.90	11.20	37.65 ab	8.70 b
100	14.21 a	112.4 a	19.81 c	22.50 b	7.82	11.27	36.80 c	8.26 c
F-test	*	*	*	**	NS	NS	**	**
LSD (0.05)	0.80	6.95	2.22	1.73	0.30	0.46	0.45	0.33
Variety								
BINA mung-7	16.34 a	125.1 a	24.33	29.95 a	7.21 b	10.81 b	29.71 b	8.80 a
BINA mung-8	10.57 b	71.0 b	23.83	16.56 b	8,44 a	11.50 a	45.32 a	8.09 b
F-test	**	**	NS	**	**	**	**	**
LSD (0.05)	0.73	6.11	1.99	1.52	0.19	0.33	0.35	0.25
CV (%)	5.79	6.93	9:05	7.28	2.96	4.07	1.70	3.89.

In a column figures having same letter (s) do not differ significantly at P < 0.05; ** indicates significant at 1% level of probability; NS = Not significant

seed yield was significant except RE (Tables 1 and 2). The plant height, branch and leaf number, leaf area, TDM, peduncle and scar number and pod number plant^{-1} were higher in BINAmung-7 which resulted the higher seed yield plant^{-1}(8.80 g plant^{-1}) than BINAmung-8.The taller plant was observed in BINa mung-7 (39.76 cm) compared to BINA mung-8 (29.60 cm). Genotypic variation in plant height was also observed by Mondal et al. (2004) in mungbean. The highest branches plant^{-1} was recorded in the treatment combination of BINAmung-7 with 100 ppm Chitosan (4.10) and the lowest was recorded in BINAmung-8 with control plants (1.00).The higher leaf area was recorded in BINAmung-7 (1605 cm 2 plant-') than the BINAmung-8 (972 cm^2 plant^{-1}). The leaf area was greater in BINAmung-7 than in BINAmung-8 due to production of higher number of leaves plant^{-1} in BTNAmung-7 compared to BINAmung-8. Variations in leaf area production were also observed by many workers in mungbaen and tomato (Poehlman, 1991; Dutta, 2001; Mondal, 2007; Rahman, 2009; Bhowal et al, 2014).On the other hand, higher harvest index, chlorophyll, nitrate reductase, photosynthesis, bolder seed

Table 3. Interaction of variety and Chitosan concentration on some morphological and biochemical characters in mungbean.

Interaction	Plant height (cm)	Branches plant $^{-1}$ (no.)	Leaves Plant $^{-1}$ (no.)	Leaf area plant $^{-1}$ (cm^2)	Chlorophyll (mg g^{-1} fw)	Nitrate reductase (µmol NO^{-2} /g fw)	Photosynthesis (µmol $C0_2S^{-1}dm^{-2}$)
BINA mung-7 × 0 ppm	35.50 b	2.70 c	20.00 c	1450 c	2.11 b	3.63 d	14.60 e
BINA mung-7 × 25 ppm	40.50 a	3.50 b	21.00 c	1560 b	2.22 b	4.13 bc	15.22 de
BINA mung-7 × 50 ppm	41:00 a	4.00 a	25.75 a	1688 a	2.30 ab	4.20 abc	16.66 bcd
BINA mung-7 × 75 ppm	41.30 a	3.95 a	24.00 b	1640 ab	2.24 b	4.10 c	16.50 bcd
BINA mung-7 × 100 ppm	40.50 a	4.10 a	24.70 ab	1690 a	2.21 b	4.25 abc	17.0 abc
BINA mung-8 × 0 ppm	26.70 f	1.00 d	9.250 e	861 e	2.27 ab	4.06 c	16.11 cd
BINA mung-8 × 25 ppm	28.20 ef	1.00 d	11.00 d	970 d	2.37 ab	4.30 abc	18.20 a
BINA mung-8 × 50 ppm	29.80 de	1.30 d	12.42 d	1021 d	2.40 ab	4.40 ab	17.92 ab
BINA mung-8 × 75 ppm	32.20 c	1.20 d	11.01 d	1000 d	2.46 ab	4.48 a	18.0 ab
BINA mung-8 × 100 ppm	31.10 cd	1.20 d	12.50 d	1011d	2.59 a	4.41 ab	17.82 ab
F-test	*	**	*	**	NS	*	*
LSD (0.05)	2.04	0.27	1.48	99.82	0.30	0.26	1.35
CV (%)	4.08	7.87	5.96	5.36	5.04	4.28	5.56

In a column figures having same letter (s) do not differ significantly at P:5 0.05; *, ** indicates significant at 5% and 1% level of probability, respectively.

Table 4. Interaction of variety and Chitosan concentration on some reproductive characters, yields attributes and seed yield in mungbean.

Interactions (variety and Chitosan)	Peduncles plant $^{-1}$ (no.)	Scars plant $^{-l}$ (no.)	Reproductive Efficiency (%)	Pods plant $^{-1}$ (no.)	Pod length (cm)	Seeds Pod $^{-1}$ (no.)	1000-seed weight (g)	Seed yield plant $^{-1}$ (g)
BINA mung-7 × 0 ppm	13.01 c	100.8 d	26.54a	26.75 c	7.00 b	10.60 b	29.43 c	7.51 cd
BINA mung-7 × 25 ppm	16.20b	114.S c	26.64a	30.50 b	7.25 b	10.80 b	30.14 b	8.93 b
BINA mung-7 × 50 ppm	17.50 a	129.2 b	26.a7 a	34.20 a	7.25 b	10.60 b	30.50 b	9.95 a
BINA mung-7 × 75 ppm	18.00 a	144.8 a	20.72 bc	30.00 b	7.30 b	11.00 ab	29.90 bc	8.88 b
BINA mung-7 ×100 ppm	17.00 ab	136.2 ab	20.78 bc	28.30 bc	7.24 b	11.05 ab	28.60 d	8.74 b
BINA mung-8 × 0 ppm	8.300 f	56.75 h	25.73 a	14.11	8.25a	11.01 ab	45.10a	7.04d
B1NA mung-8× 25 nnm	10.25 e	62.50 gh	25.56 a	16:00 de	8:50 a	11.60 ah	45:60 a	8:46 h
BINA mung-8 × 50 ppm	11.67 d	75.50 f	23.60 ab	17.70d	8.55 a	12.00 a	45.52a	8.68b
BINA mung-8 × 75 ppm	11.00 de	72.00 fg	25.42 a	18.31 d	8.50 a	11.42 ab	45.40 a	8.52 b
BINA mung-8 × 100 ppm	1 1.42 de	88.67 e	11.83 c	16.70 d	8.40a	11.50 ab	45.00 a	7.18c
F-test	*	**	*	**	NS	NS	*	*
LSD (0.05)	1.13	9.82	3.14	2.45	0.42	0.92	0.65	0.47
CV (%)	5.79	6.93	9.05	7.28	2.96	4.07	1.70	3.89

In a column figures having same letter (s) do not differ significantly at P < 0.05; ** indicates significant at 1% level of probability; NS = Not significant.

and larger pod size were recorded in BINAmung-8 but performed inferior seed $^{-l}$ yield as compared to BINAmung-7 due to fewer pods plant $^{-1}$. The chlorophyll was greater in BINAmung-8 (2.42 mg g^{-1}fw) than BINAmung-7 (2.21 mg g^{-1}fw). The higher NR was recorded in BINA mung-8 (4.33 µmol NO^{-2} /gfw) compared to BINA mung-87(4.06 µmol NO^{-2} /gfw). BINA (2007) studied with 15 mungbean genotypes and reported significant variation in NR activity in leaves. From the research findings it was reveal that the photosynthesis was higher in BINAmung-8 (17.61 µmol $C0_2S^{-1}dm^{-2}$)than BINAmung-7 (15.99 µmol $C0_2S^{-1}dm^{-2}$). Genotypic variation in photosynthesis among the mungbean genotypes was also observed by BINA (2009).

Interaction of variety and Chitosan concentration

The interaction effect ofvariety and Chitosan concentration in morphological parameters such as plant height, number of branches and leaves plant $^{-1}$, leaf area plant $^{-1}$, total dry mass plant, HI, biochemical parameters such as NR and photosynthesis, reproductive characters such as peduncle number, scar number and RE, yield attributes and seed yield was significant except chlorophyll content in leaves, pod length and number of seeds pod^{-1}(Tables 3 and 4). From the research findings it was found that the plant height increased in Chitosan applied plants in both the varieties but the increment was greater in BINA mung-7 than BINA mung-8.The highest leaf area was recorded in the treatment combination of BINAmung-7 with 100 ppm Chitosan (1690 cm^2 $plant^{-1}$). The lowest LA was recorded in the treatment combination of BINAmung-8 with control plants (861 cm^2 $plant^{-1}$).The interaction effect of variety and Chitosan concentration in chlorophyll content in leaves was non-significant. The highest NR activity was recorded in BINAmung-8 with75 ppm Chitosan (4.48 µmol NO^{-2} /gfw). The lowest NR activity was recorded in BINAmung-7 with control plant (3.63 µmol NO^{-} ^{2} /gfw). The highest photosynthesis was recorded in BINAmung-8 with 25 ppm Chitosan concentration (18.20 µmol $C0_2S^{-1}dm^{-2}$)and the lowest was recorded in BINAmung-7 with control plants (14.60 µmol $C0_2S^{-1}dm^{-2}$).

Conclusion

Foliar application of Chitosan at vegetative stage (30 DAS) and at flower initiation stage (40 DAS) had significant influence on plant characters, yield attributes and fruit yield of mungbean over control. Application of Chitosan @ 50 ppm had superiority for plant growth, yield components and yield over 25, 75 and 100 ppm. So, we may recommend to use of 50 ppm of Chitosan for getting maximum seed yield in mungbean variety.

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