Irradiated foxtail millet (*Setaria italica* (L.) P. Beauv.): agronomic and physiological performances under low light intensity

T Juhaeti¹

¹Botany Division, Research Center for Biology, Indonesian Institutes of Sciences Jl. Raya Jakarta Bogor km 46 Cibinong 16911 Indonesia

E-mail: titi001@lipi.go.id

**Abstract.** The research was carried out to study the agronomic and physiological performances of gamma rays Irradiated Foxtail Millet (IFM) under low light intensity as an effort to obtain a shade-tolerant mutant. The experiment was performed in a Randomized Complete Block Design (RCBD) with two factors. The first factor was shading intensities, whereas the second factor was foxtail millet mutants resulting from gamma rays irradiation. The observation was performed on agronomic and physiological parameters, including plant growth, chlorophyll content (CC), photosynthesis rate (PR), and panicle production (PP). The result of this study showed that low light intensity decreased CC and PR values. The statistical analysis showed that CC value in 50% shading (33.02SPAD) was significantly different with 0% shading (47.56 SPAD). Accordingly to this result, the PR value at 50% shading (7.112µmolm⁻²s⁻¹) presented a significant difference as compared to 0% shading (19.379µmolm⁻²s⁻¹). Observations on the plant height of GM 75.16 showed no significant difference with the control plants. Similarly, the result of PP on GM75.16 (17.03g) was not significantly different as compared to the control (16.24 g) and GM75.14 (14.10g). Therefore, GM 75.16 was identified as a shade-tolerant mutant due to its ability to sustain the growth and development under low light intensity.

1. Introduction

Indonesia has a lot of plant biodiversity that is potential to be developed for food diversification, in which one of them is foxtail millet (*Setaria italica* (L.) P. Beauv.). There are many vernacular names of foxtail millet in Indonesia, for example, *juwawut* (Central Java), *kunyit* (Tasik, West Java), *tarreang* (Polewali Mandar, West Sulawesi), *hotong* (Buru, Maluku), *pokem* (Numfor, Papua), *witi* (Bima), *ba’tang* (Enrekang, South Sulawesi) and *sekoì* (Bengkulu). Foxtail millet is an old crop that has been planted since 5000 BC in China and 3000 BC in Europe, from where it spread to India and Europe. At present, foxtail millet is cultivated all over the world [1, 2].

The observations of the Research Center for Biology, Indonesian Institutes of Sciences showed that until now, foxtail millet is still planted and consumed in several regions in Indonesia, although on a small scale, such as in West Sulawesi, Sumba, Papua, Buru Island, and Central Java. Local people cooked foxtail millet into porridge and many traditional cakes. The local people in Sidrap South Sulawesi created a variety of millet culinary mixed with brown sugar and coconut. In Buru island, local people cooked foxtail millet become traditional food such as porridge, *nasi*, and wajit [3]. Researcher at Biology Research Center processed millet flour into various tasty and nutritious bread, cookies, and cakes. Finally, millet flour is expected to reduce wheat flour consumption.
In rural India, foxtail millet is used as a nutritional source for pregnant and lactating mothers, also for sick people and children [2]. Millet is known to be one of the most digestible and non-allergenic grains, three times superior to rice and wheat in terms of proteins, minerals, and vitamins [4]. Foxtail millet, like other types of grains (millet), contains high nutrients compared to wheat, corn and rice, high protein and antioxidant content, and a low glycemic index value that is suitable for diabetics [5,6].

In global trade, India is one of the producer and exporter countries of millet [7]. Nowadays, foxtail millet becomes a minor plant left out by the existence of major food plants such as rice and corn. In the 1970s, local communities in Ciamis, Tasikmalaya, and Cianjur, West Java, Indonesia were still familiar and consumed foxtail millet as rice and/or porridge. In the village of Jamokusuman, Kluwar, Magelang regency, Central Java, in the 1960s, farmers still planted foxtail millet in rice fields. They consumed it as porridge or onde-onde cookies (Gito, personal communication 2019), but, at present, foxtail millet is no longer found in these areas. At Borobudur Temple, Central Java, there are beliefs about foxtail millet together with several other food commodities. Foxtail is carved in detail, and stems appear erect and small with single leaves, intermittent, and tapered at the tip; panicles appear like hair [8].

The utilization of foxtail millet for food diversification is not intended to replace rice, but rather to enrich the types of food sources to consume. The utilization of millet as an ingredient in making many cookies is expected to reduce dependency on wheat flour. The increase in foxtail consumption must be accompanied by market availability at affordable prices. So, foxtail millet cultivation should be expanded. The cultivation is suggested directed on marginal areas, such as shading areas on young plantations. The utilization of young plantations and forestry land is one of the efforts that can be done to maintain national food supplies [9]. The potential of land below the standing plant area on private/state plantations is quite large, reaching 12.1 million ha. Every year, around 3-4% of the plantation area is a new plant (replanting), which can be used for the development of inter-cropped plants until the plantation is three years old [10].

It is known that foxtail millet is sensitive to shade conditions [11]. The optimum vegetative and generative performances of foxtail millet were in full sun (0% shading) condition. The foxtail millet still grew and produced grain on cultivation in 25-50% shading intensity, although its panicle production decreased until 44.27-50%. So, to obtain shade-tolerant foxtail millet mutants resulting from gamma rays irradiation, several gamma-ray irradiations on foxtail millet accession were observed under 50% shade conditions.

The availability of shading tolerant foxtail millet varieties is required. Meanwhile, the research to obtain shade-tolerant foxtail millet is still limited. Therefore, this research aimed to determine the physiology and performance of M1 foxtail millet mutants (from gamma-ray radiation) to low light intensity conditions to obtain shade-tolerant variety.

2. Materials and methods
The study was conducted at the experimental garden facility in the Botany Division, Research Center for Biology, Cibinong, West Java, from December 2018 to April 2019. The experiment was designed in a Randomized Complete Block Design (RCBD) with two factors. The first factor consisted of two levels of shading intensity, i.e. 0% and 50%. The second factor was composed of seven foxtail millet accessions resulting from gamma-ray irradiations, namely GM75.16, GM25.12, M2GM3, GM100.10, GM75.14, GM100.20, and GM0.5 (as the control plants, without irradiation). There were eight replications in every treatment, in which each replication consisted of 3 plants observed.

The plastic black para nets were applied to an artificial shading building for setting up 50% of shading intensity. The artificial shadings were made in the form of a simple rectangular building covering the plants from the soil surface. The height of the artificial building was 3 meters, the length was 5 meters, and the width was 5 meters.

This research started with the germination process of foxtail millet seeds inside the greenhouse. The germination medium was composed of the mixture of sand: soil: compost in the ratio of 1:1:1. After three weeks of the germination process, the seedlings were then planted on polybags (30x40 cm) with the growth medium was a mixture of soil: compost: manure in the ratio of 2:1:1. The seedlings
were then acclimatized for one week to get uniform growth. The uniform seedlings on each polybag were then placed on each shading treatment, stated as 0 weeks of plant observation (weeks after germination). The fertilizers of urea, TSP, and KCL at a dose of 2-1-1g/polybag were added as the basic fertilizer in the medium to supply the plant nutrient during the growth and development stages.

The microclimate on shading building, including temperature, humidity, and light intensity, was observed daily at 09.00 am, 12.00 am, and 15.00 pm. The temperature and humidity on shading treatments were measured using a Digital Thermohygrometer AS ONE TH-321 (Corona). The light intensity was measured by lux meter (LUXOR). The plant observed variables included plant growth, chlorophyll content (CC), photosynthesis rate (PR), and panicle production (PP). The chlorophyll content was measured by The Soil Plant Analysis Development (SPAD) chlorophyll meter Minolta Seri SPAD-502Plus. The measurement of photosynthesis rate used the LCI ADC Bioscientific Ltd. The grain harvesting was done when about 90% of panicles had matured, which was indicated by panicle becoming dry and brownish at 10 weeks after planting (WAP).

Data obtained from the treatment were analyzed using SAS 9.1 software with a two-way analysis of variance (ANOVA) with a 5% level of confidence. If there is a significant effect between treatments, further testing will be done using the DMRT test at the level of 5%.

3. Results and discussion

3.1. Microclimate condition on shading building

The macroclimate was not intensively observed during this study. The intensive observation was done on microclimate inside artificial shading building. The results of microclimate observations showed the differences in the 0% and 50% shade conditions. The temperature and humidity seemed not too different, but the light intensity was very different (Table 1).

| Observation Time /Shading | Temperature (°C) | Humidity (%) | Light intensity (lux) |
|---------------------------|-----------------|--------------|----------------------|
|                           | 0% | 50% | 0% | 50% | 0% | 50% |
| 09.00 am                  | 30.8±1.1 | 30.9±1.1 | 63.7±6.6 | 65.7±4.2 | 48.7±6.2 | 18.0±6.9 |
| 12.00 am                  | 31.4±3.6 | 31±1.8 | 66.5±11.0 | 66±6.8 | 75.9±16.4 | 29.7±17.5 |
| 15.00 pm                  | 29.6±1.1 | 30.1±1.7 | 67.6±5.1 | 65.2±7.0 | 22.3±8.0 | 14.9±6.3 |

Noted: mean±standard deviation.

3.2. The effect of a single factor of foxtail millet mutants

The discussion of irradiated mutants of foxtail millet as a single factor treatment was done by ignoring observation value on the shading treatments. Therefore, the data presented in Table 2 were obtained from a compilation of both 0 and 50% shading conditions.

As presented in Table 2, the observation result of each foxtail millet mutant showed a significant difference between the parameters of plant height and leaf number. Three weeks after planting (WAP), GM25.12 mutant showed the highest result of plant height (62.18 cm), which is significantly different (at 5% DMRT test P-value) from the control plant GM0.5 (56.15 cm). The result in Table 2 also shows the significant difference of leaf number parameter in between irradiated mutants of foxtail millet plants (IFM). The highest value of leaf number (8.58) was produced by GM25.12 and M2GM3 mutants, which both were not significantly different from GM0.5 mutant with leaf number value of 8.22.

The foxtail millet mutants also showed the differences in chlorophyll content at one until six weeks after planting (WAP, Table 2). Six weeks after planting (WAP), both GM100.10 and GM0.5 mutants showed the highest chlorophyll content (49.21 SPAD), which were significantly different from GM100.20 mutant (45.26 SPAD). The high chlorophyll content of tested foxtail millet mutants was expected to increase their photosynthesis rates and finally improved plant growth and production. But,
in this research, the photosynthesis rates have no significantly different value in between all foxtail millet mutants observed. Therefore, it is suggested to observe daily photosynthesis rates of the plant.

Table 2. The responses of IFM on plant height and leaf number parameter.

| Foxtail millet mutants | GM75.16 | GM25.12 | M2G3M | GM100.10 | GM75.14 | GM0.5 | GM100.20 |
|------------------------|---------|---------|-------|-----------|---------|-------|---------|
| Plant height (cm) (n) Weeks After Planting (WAP) | | | | | | | |
| 1 WAP | 22.4±3.2d | 27.9±2.6 a | 24.0±2.9cd | 27.9±3.4a | 25.4±2.9bc | 24.5±2.4cd | 27.4±3.7ab |
| 2 WAP | 36.9±5.2d | 43.8±4.3a | 39.3±4.5bcd | 42.4±6.1ab | 42.0±5.6bc | 38.9±5.9cd | 43.7±5.1a |
| 3 WAP | 52.4±12.5c | 62.2±11.0a | 58.0±10.7ab | 59.7±13.4ab | 55.6±11.4bc | 56.2±12.7bc | 62.0±9.4 a |
| Leaf number on (n) Weeks After Planting (WAP) | | | | | | | |
| 1 WAP | 4.9±0.5bc | 5.3±0.5 a | 5.0±0.4abc | 5.3±0.5ab | 4.8±0.3c | 5.0±0.3abc | 5.0±0.3abc |
| 2 WAP | 6.5±0.8 a | 6.7±0.6 a | 6.6±0.9a | 6.4±1.0 a | 6.4±0.8 a | 6.5±1.0 a | 6.7±0.7 a |
| 3 WAP | 7.8±1.1 b | 8.6±1.1ab | 8.6±1.2ab | 8.3±1.5ab | 8.3±1.0ab | 8.2±1.5 a | 8.7±0.8 a |

Chlorophyll Content (SPAD) on (n) Weeks After Planting (WAP)

| Plant Biomass at Harvesting Time | GM75.16 | GM25.12 | M2G3M | GM100.10 | GM75.14 | GM0.5 | GM100.20 |
|---------------------------------|---------|---------|-------|-----------|---------|-------|---------|
| Panicle length (cm) | 152.2±17.57a b | 139.1±18.02c | 154.2±17.16a | 142.8±19.75bc | 155.8±12.56a | 158.0±18.25a | 148.4±19.20ab c |
| Shoot dry weight (g) | 10.2±4.36ab | 7.9±4.36c | 9.0±4.33bc | 9.4±4.07b | 9.7±4.58b | 11.2±5.66a | 10.0±5.99ab |
| Root dry weight (g) | 2.0±1.26ab | 1.6±1.26c | 1.9±1.23bc | 1.9±1.34abc | 1.8±1.25b | 2.3±1.43a | 2.0±1.42ab |

Plant production

| Peduncle length (cm) | 11.6±2.75 ab | 12.14±4.08 ab | 13.75±4.56 a | 13.73±3.1 a | 12.29±2.56 ab | 10.97±4.28 b | 12.13±3.6 ab |
| Panicle length (cm) | 20.9±3.93 a | 18.50±3.47 b | 20.58±4.01 a | 20.08±4.2 ab | 20.94±2.59 a | 20.31±4.05a | 19.98±3.38 b |
| Panicle weight (g) | 17.03±7.92 a | 12.4±8.92 c | 13.9±7.5bc | 13.16±6.90c | 14.10±6.87abc | 16.24±5.73ab | 11.38±5.31c |

Noted: The value of observation (mean±standard deviation) followed by the same letter on the same line indicated no significant difference on 5% DMRT Test.

At the harvesting time, the plant height and biomass parameters were significantly different among IFM (Table 2). The GM75.16 mutant produced higher biomass than others, which were not significantly different from the GM0.5 mutant. For the plant production (Table 2), the GM75.16 mutant also generated the highest panicle weight with an average value of 17.03 g. According to this result, the GM75.16 mutant was determined as a candidate for a shade-tolerant mutant.

3.3. The effect of a single factor of shading treatment

As shown in Table 3, the 50% light intensity affected plant growth and productivity (Table 3). Foxtail millet planted on the 50% light intensity produced the values of plant height and leaf number, which were lower than the control plant. On low light intensity, the chlorophyll content decreased significantly. Low light intensity also affected photosynthesis rates. Light is a vital component of the photosynthesis process. Meanwhile, shading reduces the light intensity, which leads to changes in the morphology, physiology, biomass, grain yield, and quality of crops. Shading stress also delays flowering and decreases biomass and grain yield. Reduced light is known to limit carbon accumulation and nitrogen content [12]. The decrease in plant growth on low light intensity conditions ultimately decreased plant production [13].

3.4. The effect of the interaction of shading treatment and IFM

The ANOVA analysis showed that there was no significant interaction between foxtail millet mutants and shading intensities on all parameters observed. Generally, the irradiated foxtail millet (IFM) mutants presented the growth and production, which tended to decline as compared to control GM0.5 (non-irradiated foxtail millet). However, GM75.16 mutant presented a lower percentage reduction in
all parameters of plant growth and production, except root fresh weight, panicle length, and panicle weight, as compared to a non-irradiated mutant, GM0.5 (Table 4).

Table 3. The effect of shading on plant growth and production.

| Shading intensity(%) | 0       | 50      |
|----------------------|---------|---------|
| Plant height (cm) on (n) Weeks After Planting (WAP) |         |         |
| 0 WAP                | 19.48±2.42a | 19.24±2.32a |
| 1 WAP                | 25.75±2.85a | 25.51±2.82a |
| 2 WAP                | 44.09±3.86a | 37.34±3.81b |
| 3 WAP                | 68.23±4.74a | 47.76±6.16b |
| Leaf number on (n) Weeks After Planting (WAP) |         |         |
| 0WAP                 | 3.86±0.34a  | 3.85±0.36a  |
| 1 WAP                | 5.17±0.49a  | 4.94±0.42 b |
| 2 WAP                | 7.12±0.67a  | 5.95±0.57b  |
| 3 WAP                | 9.29±0.73a  | 7.41±0.80b  |
| Chlorophyll content (SPAD) on (n) Weeks After Planting (WAP) |         |         |
| 1 WAP                | 29.66±2.08a | 27.06±1.21b |
| 2 WAP                | 39.31±1.44a | 30.08±1.67b |
| 3 WAP                | 47.56±1.63a | 33.01±1.67b |
| 6 WAP                | 50.27±6.82a | 45.43±1.57b |
| Photosynthesis Rates (µmol m⁻² s⁻¹) |         |         |
| Photosynthesis rates | 19.38±6.82a | 7.11±1.57b  |
| Biomass at harvest time |         |         |
| Plant height (cm)    | 161.05±4.37a | 139.08±5.76b |
| Shoot dry weight (g) | 13.69±0.79a  | 5.55±0.32b  |
| Root dry weight (g)  | 3.08±0.22a   | 0.82±0.08b  |
| Plant production     |         |         |
| Peduncle length (cm) | 14.06±0.74a  | 10.78±0.93b |
| Panicle length (cm)  | 22.85±1.13a  | 17.52±0.68b |
| Panicle weight (g)   | 19.84±2.29a  | 8.23±0.88b  |

Noted: The value of observation (mean±standard deviation) followed by the same letter on the same line indicated no significant difference on 5% DMRT Test.

Table 4. Decreased percentage of plant growth and production at the low light condition.

| Plant height (%) | Shoot fresh weight (%) | Root fresh weight (%) | Shoot dry weight (%) | Root dry weight (%) | Peduncle length (%) | Panicle length (%) | Panicle weight (%) |
|------------------|------------------------|-----------------------|---------------------|--------------------|--------------------|-------------------|-------------------|
| GM75.16          | 9.2±6.2           | 55.8±11.5            | 68.7±4.6            | 52.7±10.4          | 66.7±12.0          | 10.2±4.7          | 22.3±13.8         | 54.4±10.3         |
| GM25.12          | 11.8±5.4          | 61.4±12.3            | 76.0±10.8           | 58.4±12.1          | 72.3±10.3          | 20.0±12.7         | 20.4±15.2         | 64.7±10.5         |
| M2GM3            | 13.5±4.6          | 74.0±10.1            | 78.9±5.3            | 58.2±5.7           | 74.9±8.8           | 38.3±18.5         | 28.9±13.7         | 68.1±11.6         |
| GM100.10         | 17.2±3.7          | 57.5±6.5             | 86.7±7.27           | 57.0±4.3           | 76.9±4.5           | 11.47±8.7         | 29.2±6.9          | 56.0±5.2          |
| GM75.14          | 10.7±3.01         | 68.4±9.8             | 75.1±8.5            | 58.6±3.9           | 78.0±6.2           | 32.4±10.4         | 19.0±5.1          | 60.9±13.8         |
| GM0.5            | 18.1±6.6          | 72.7±12.7            | 66.5±14.0           | 62.7±10.1          | 69.5±13.7          | 41.2±12.6         | 17.2±8.8          | 52.5±9.5          |
| GM100.20         | 16.4±4.8          | 65.0±11.4            | 62.7±7.5            | 68.4±5.0           | 76.3±9.1           | 17.6±13.3         | 26.0±11.5         | 52.8±12.6         |

Noted: mean± standard deviation.

Shading intensity significantly affected plant growth and production. The result of observation showed that leaf chlorophyll content as a photosynthesis agent decreased on shading conditions (Figure 1). Therefore, it affected photosynthesis reactions to the plants observed. The research showed
that photosynthesis rates highly correlated with Q leaf (Figure 1) on all of the IFM observed. Higher Q leaf generated higher photosynthesis rates, with R² value in between 0.651-0.933.

Figure 1. Correlation between Q leaf and photosynthesis rates.

Foxtail millet is a C4 plant. The high energy cost and low plasticity of C₄ photosynthesis compared with C₃ photosynthesis may limit the productivity and distribution of C₄ plants in low light (LL) environments [14]. The research showed that the metabolism on foxtail millet was significantly affected by shading conditions (light intensity). The plant growth and production decreased in low
light intensity conditions. Low light penetration on the canopy reduced photosynthesis and plant yield [15]. Biomass accumulation is dependent on radiation use efficiency and light interception [16]. The optimum vegetative and generative performances were on 0% shading condition. The plant biomass weight on shade conditions was lower as a result of decreasing photosynthesis rates. The shading intensity caused a reduction of the light intensity that was required for photosynthesis, resulting in a decrease in assimilation products [17] and finally decreasing plant biomass dry weight [18]. The effect of shade on upland rice varieties decreased the number of tillers, number of panicles, number of productive grains, grain production per hill of upland rice plants, and total sugar content of upland rice plants [18]. Shading conditions also significantly affected all of crop production variables as a result of decreasing photosynthesis rates. Under normal conditions, plants will allocate energy and nutrient for plant growth and production. But, under stress conditions, plants will use much more energy and nutrient for their survival [19]. The parameters of the fresh grain mass per panicle, yield, photosynthetic pigment contents, net photosynthetic rate, stomatal conductance, the effective quantum yield of PSII photochemistry, and electron transport rate decreased with the increase of shading intensity. Shading also changed a double-peak diurnal variation of photosynthesis to a one-peak curve. The lower yield of foxtail millet was caused mainly by a reduction of grain mass assimilated, a decline in chlorophyll content, and a low photosynthetic rate due to low light during the grain-filling stage. Reduced light energy absorption and conversion, restricted electron transfer, and reduced stomatal conductance might cause a decrease in photosynthesis [20].

4. Conclusion
In this study, it can be concluded that low light intensity decreased plant growth and production by lowering chlorophyll content and photosynthesis rates. The mutant of G75.16 was determined as a potential low-light tolerant mutant for its better growth and production compared with others. The highest grain production achieved on the G75.16 mutant. Further research is needed to observe the stability of these G75.16 mutant characters for developing the cultivation of shading tolerant foxtail millet on low light intensity.

Acknowledgment
The author gratefully thanks to Plant Bio-Prospecting Project of Research Center for Biology, Indonesian Institutes of Sciences for funding this research. The author also would like to thank Dr. Dwi Setyo Rini for the manuscript correction and Indra Gunawan for helping in the garden along the research periods.

5. References
[1] Plant Resources of Tropical Africa 2015 Setaria italica [Online] accessed from https://uses.plantnet-project.org/en/Setaria_italica_(PROTA)
[2] Hariprasana K 2016 Nutritional importance and cultivation aspects Indian farming 65: 25-9
[3] Badan Penelitian dan Pengembangan Pertanian 2016 Optimizing the utilization of plant and animal genetic resources: Responding to food security policies, ed T Alihamsyah et al (Jakarta: IAARD Press) p 736
[4] Kamatar MY, Brunda SM, Rajaput S, Sowmya HH, Goudar G and Hundekar R 2015 Nutritional composition of seventy five elite germplasm of foxtail millet(Setaria italica) Int. J. Engineering Res. and Technol. 4: 1-6
[5] Himanshu, Chauchan M, Sonawane SK and Arya SS2018 Nutritional and nutraceutical properties of millets a review Clinical J.of Nutrition and Dietetics 1: 1-10
[6] Wahlang B, Joshi N and Ravindra U 2018 Glycemic index lowering effect of different edible coatings in foxtail millet J. of Nutritional health and food engineering 8: 404-408
[7] Seair Exim Solution 2016 Foxtail millet export data of India and price [Online] accessed from https://www.seair.co.in/foxtail-millet-export-data.aspx
[8] Balai Konservasi Borobudur 2017 Juwawut [Online] accessed from https://kebudayaan.kemdikbud.go.id/bkborobudur/juwawut/
[9] Junaedi D 2000 Adaptation test of selected upland rice lines (Oryza sativa L.) at several shading levels (in Indonesian) [Skripsi] (Bogor: IPB)
[10] Sopandie D dan Trikoesoemaningtyas 2011 Intercropping development under annual plant stands Iptek Tanaman Pangan 6: 168-182
[11] Juhaeti T 2019 Cultivation of foxtail millet (Setaria Italic (L) P. Beauv) under low light intensity and its response to nitrogen fertilization Prosiding Seminar Nasional Biologi 4 Pemanfaatan Biodiversitas dan Bioteknologi untuk Pelestarian Lingkungan pp480-5
[12] Parande S, Eslami S V and Jami al Ahmadi M 2019 Effects of shading and nitrogen on phenology and yield of foxtail millet (Setaria italica L.) in competition with white pigweed (Amaranthus albus L.) [Online] accessed from http://agris.fao.org/agris-search/search.do?recordID=IR2019700074
[13] Faisal MMT 2014 Flag leaf characteristics and relationship with grain yield and grain protein percentage for three cereals J. of Medicinal Plants Studies 2: 1-7
[14] Balasaheb VS, Robert ES, Spencer W and Oula G 2018 Shade compromises the photosynthetic efficiency of NADP-ME less than that of PEP-CK and NAD-ME C₄ grasses J. Exp. Bot. 69: 3053–68
[15] Nandini K M and Sridhara S 2019 Response of growth yield and quality parameters of foxtail millet genotypes to different planting density Intl. J. Curr. Microbiol. App. Sci. 8: 1765-73
[16] Sankalpi N W and Thomas P B 2014 Enhancing the productivity of grasses under high density planting by engineering light responses; from model system to feedstocks J. of Exp. Botany 65: 2825-34
[17] Lambers H and Hendrik P 1992 Inherent variation in growth rate between higher plants: A search for physiological causes and ecological consequences Adv. Ecol. Res. 23: 187-261
[18] Ginting J, Damanik B S J, Jamuda M S and Chairul M 2015 Effect of shade, organic materials and varieties on growth and production of upland rice Int. J. of Sci. & Technol. Res. 4: 68-74
[19] Prasch CM and Uwe S2015Signaling events in plants: Stress factors in combination change the picture Environmental and Exp. Botany 114: 4-14
[20] Yuan X, Zhang L G, Huang L and Guo P Y 2016 Photosynthetic and physiological responses of foxtail millet (Setaria italica L.) to low-light stress during grain-filling stage Photosynthetica 55: 491-500