ISSN NO : 2523-1189
Journal of AGRICULTURAL AND RURAL RESEARCH

GROWTH AND YIELD OF POTATO AS INFLUENCED BY ORGANIC AND INORGANIC SOURCES OF PLANT NUTRIENTS

G.M. Jahangir Kabir, Farjana Sultana, Md. Talha Zubair, Mahbub Robbani and Mohammad Ali

To cite the article: G.M. Jahangir Kabir, Farjana Sultana, Md. Talha Zubair, Mahbub Robbani and Mohammad Ali (2021), Growth and yield of potato as influenced by organic and inorganic sources of plant nutrients, *Journal of Agricultural and Rural Research*, 6(1): 01-15.

Link to this article:
http://aiipub.com/journals/jarr-210408-010118/

GROWTH AND YIELD OF POTATO AS INFLUENCED BY ORGANIC AND INORGANIC SOURCES OF PLANT NUTRIENTS

G.M. Jahangir Kabir, Farjana Sultana, Md. Talha Zubair, Mahbub Robbani and Mohammad Ali

Department of Horticulture, Patuakhali Science and Technology University Dumki, Patuakhali, Bangladesh.

Author for correspondence

G.M. Jahangir Kabir

Email: jkabirddj@gmail.com

ARTICLE INFO

Article Type: Research

Received: 04, Feb. 2021.

Accepted: 08, April. 2021

Published: 11, April. 2021

Keywords:

Growth and yield, potato, organic manure and inorganic fertilizer

ABSTRACT

An experiment was carried out at the Regional Horticulture Research Center (RHRC), Lebukhali, Dumki, Patuakhali during the period from November 2011 to March 2012 to study the effect of inorganic fertilizers and organic manures on the growth and yield of potato. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and consisted of two factors. Organic manures and inorganic fertilizers and their treatment combinations showed a significant difference in respect of all growth and yield contributing characters of potato. The tallest plant (44.07 cm) and the maximum number of tuber (227.7) plot-1 were found from the F3M1 treatment at 75 DAP. A similar treatment combination also gave significantly the higher foliage coverage (40.47%), highest weight of fresh haulm (82.62 g) and dry haulm (10.09 g). The F3M1 treatment gained the highest gross yield (43.15 t ha-1) and marketable yield (43.03 t ha-1). The lowest scab percentage (0.28%) was also observed in F3M1 treatment. The study suggested that combination of 312.5 kg ha-1 Urea + 187.5 kg ha-1 TSP + 312.5 kg ha-1 MOP +15 t/ha cowdung (F3M1 treatment) can contribute the improvement of growth, yield and yield contributing character of potato.

INTRODUCTION

Potato *(Solanum tuberosum L.)* is an important horticultural crop worldwide used as human food as well as animal feed. In Bangladesh, potato ranks the highest vegetable crop in terms of hectare accounting for 293 thousand hectares, yielding 32,00,000 (BBS, 2007). The tubers are boiled or steamed, baked, roasted, or used as chips. In our country the average yield of potato is very low (12 t/ha) compared to those of other potato growing countries like Netherlands (42 t/ha) (FAO, 2002). Low soil fertility is a major constraint to potato production in most parts of Bangladesh besides insect pests and diseases. The growth parameters and the yield gradually increased with the increase in the rate of organic matter (Ahmed, 2004).

In Bangladesh, potato is the 3rd most important crop followed by rice and wheat. It is commonly used as vegetables in Bangladesh and could contribute to poverty alleviation and food security with a wide range of the adaptability of soil and climate. It alone contributes to about 63% of total annual vegetable production in Bangladesh (BBS, 2009). Potato varieties grown in Bangladesh may be divided into two groups namely, the local or indigenous and the high yielding or modern. The modern varieties of potato include those breed in the recent past, especially varieties introduced to Bangladesh after 1960 are designated as modern (Hashem, 1990). These varieties are characterized by relatively bigger tubers higher yield and fewer but thicker stems with bigger leaves (Rashid *et al.,* 1987) and better response to applied inputs such as water, manures and fertilizers.

Maximum cultivation and production of potato were found in the district of Dinajpur, Thakurgaon, Bogra, Joypurhat, Nilphamari and Munshigonj in Bangladesh. The development of this crop in Bangladesh has not been encouraging. As can be seen from Appendix III, the average yield of potatoes in Bangladesh remained more or less static during the year from 1995 to 2009 (BBS, 2009).

Fertilizers are one of the most important inputs of increasing the productivity of crops and modern varieties of different crops (Anonymous, 1997; Ali *et al.*, 2009). Fertilizer application has important effects on the quality and yield of potatoes (Leytem and Westermann, 2005). Potato is highly responsive to N fertilization and N is usually the most limiting essential nutrient for potatoes growth, especially on sandy soils (Errebhi *et al.*, 1998). Nitrogen supply also plays an important role in the balance between vegetative and reproductive growth for potatoes (Alva, 2004; White *et al.*, 2007). Many previous studies have shown that fertilizer N applications can increase dry matter content, protein content of potato tubers, total and/or marketable tuber yield (Bélanger *et al.*, 2002; Kara, 2002; Zebarth *et al.*, 2004; Zelalem *et al.*, 2009; Ruiz *et al.*, 1999).
Organic material is used to prevent or improve the negative stress effects in plants and yield decreases. It is material to decrease soil salinity, increase the organic matter, improve the soil structure and increase water and air permeability by root developing in soil. It is one of the best-used fertilizers (Anonymous, 2010; Hassanpanah and Jafar, 2012). Nitrogen fertilization was reported to increase the average fresh tuber, plant height, leaf number and tuber, weight per plant responded positively application and Leaf area increased (Kandil *et al.,* 2011; Ruiz *et al.*, 1999; Semiha., 2009). In contrast to this, it was found that nitrogen fertilization had a negative effect on the time of emergence and little or no effect on yield. Due to the poor soil organic matter content in southern Algeria, organic fertilizers are indispensable for potato cultivation. Research found that combination of various level of Farmyard manure and nitrogen statistically ($p \leq 0.05$) affected leaf area, plant height, leaf length, leaf number, leaf diameter, stem diameter and stem number (Khandaker *et al.*, 2017).
In this area, farmers often use expensive chicken manure as an organic fertilizer for potato production. Organic fertilizers are indispensable for potato cultivation in this zone after using expensive manure may offer farmers an equally effective, but less expensive alternative to manure or use mixed manure (organic manure and inorganic N P K fertilizer). Considering the above situation, the present study was undertaken to find out the most optimum dose of manures and appropriate dose of fertilizer as well as the suitable combination for the better growth and yield of potato.

MATERIALS AND METHODS

Experimental site and planting materials
The experiment was conducted at the Regional Horticulture Research Center (RHRC) at Lebukhali, Patuakhali (22037˚ N latitude and 89010˚ E longitudes) during the period from November, 2011 to March, 2012. Soil characteristics of the RHRC research farm are silty loams or alluvium. However, the soil of the experimental field was silty clay loam having a pH value of 6.8. The potato variety used in the experiment was “Diamant”. The seed tuber was collected from Bangladesh Agriculture Research Institute (BARI).
Design and layout of the experiment
The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Firstly, the entire experimental plot was divided into three blocks. Each block consisted of 16 unit plots and each receiving a treatment combination of the experiment. Treatment combinations of the experiment were assigned randomly in each block. Thus the total numbers of plots were 48, where block to block and plot to plot spacing were 0.5 m and 0.3 m, respectively. However, each plot was 2.7 m^2 where plot length and wide was 1.8 m × 1.5 m. The standard procedure was followed during the land preparation and intercultural operations were done as needed.
Treatments of the experiment
The two factors experiment consisted of manures and fertilizer in this experiment. The treatments were as follows–
Factor A
F0 = No fertilizer (Control)
F1 = 187.5 kg ha-1 Urea + 112.5 kg ha-1 TSP + 187.5 kg ha-1 MOP

F2 = 250 kg ha-1 Urea + 150 kg ha-1 TSP + 250 kg ha-1 MOP
F3 = 312.5kg ha-1 Urea + 312.5 kg ha-1 TSP + 187.5 kg ha-1 MOP
Factor B
M0 = Control (No manure)
M1 = Cowdung (15 ton ha-1)
M2 = Poultry dropping (5 ton ha-1)
M3 = Mustard Oil Cake (2 ton ha-1)

Data collection

Data were recorded on the following parameters from the sample plants during the course of the experiment. The sampling was done randomly. Ten plants were selected at random from each unit plot to collect the experimental data. The plants at the extreme end in the rows were excluded to avoid the border effect for the highest precision. The height of plants was measured in centimeter by a meter scale from the ground level to the top of the longest shoot at the unit plot at 45, 60 and 75 days after planting, from 10 sample plants mean was calculated and presented. The area covered by the canopy of the sample plants was calculated and converted into a percentage. The average was taken as foliage coverage per plant. The number of main stems per hill was calculated from 10 plants selected at random from each unit plot and mean was calculated. The fresh weight of haulm was taken from sample plants in grams at the time of haulm cutting and the average was calculated for determining the fresh weight of haulm. A dry weight of haulm was taken from oven-dried oven specification fresh haulm hill–1, where the fresh haulm was oven dried for 72 hours at 80 0C in an oven just after sun drying for two days. The number of tubers hill–1 was recorded after harvesting of 10 sample plants from each unit plot and the average number of tubers was calculated. The gross yield of tubers plot–1 was recorded at the time of harvesting. The tubers from all plants of a unified plot and the yield of tubers per plot were converted into kg plot–1. The marketable yield of tubers ha–1 was calculated from that of plot–1 yield and expressed as a ton.

Statistical analysis

The collected data on various parameters under study were statistically analyzed according to the principles of experimental design to find out the statistical significance of the experimental results. The means for all the characters were separated by Least Significance Difference (LSD) and Duncan’s Multiple Range Test (DMRT) test at 5% level of probability (Gomez and Gomez, 1984) using the statistical computer package program, MSTAT-C (Russell,1986).

For economic analysis, all the non–materials and materials input costs and interest on fixed (land) and running capital were considered for calculating the cost of production. The benefit-cost ratio (BCR) was calculated by the following formula:

Benefit cost ratio (BCR) =Gross return (Tk/ha)/ (Total cost of production (Tk/ha)

RESULTS AND DISCUSSION

Plant height

The plant height was significantly influenced by inorganic fertilizer on different days after planting (DAP). The tallest plant (40.95 cm) was observed from F3 treatment which was followed by F2 treatment (30.8 cm) and the shortest plant (26.55 cm) was recorded from control treatment (F0) at 75 days after planting (DAP) (Fig.1A). Similar results were also observed at 30 and 45 days after planting. This finding is in accordance with the observation of Adeyemi *et al.* (1987) and Ajari *et al.,* 2003. The height of the potato plant was recorded on different days after planting (DAP) viz. 45, 60 and75 DAP where they showed significant variation among the main effect of different levels of organic manures. Among the different organic manures, the tallest plant (37.35 cm, 36.03 cm and 35.58 cm, respectively) were obtained from the M1 (4 kg cow dung), M2 (1.35 kg poultry dropping) and M3 (1/2 kg MOC) treatment, respectively at 15 days after planting. While the shortest plant (34.66 cm) was found from the control plot at 75 DAP. Similar trends of results were also observed at 30 and 45 days after planting, respectively (Fig. 1B). These results exposed that the height of potato plants significantly increased with the growing levels of cow dung. The higher levels of cowdung improved the soil fertility, more uptake the soil nutrient, as well as they, produce the higher growth of a plant. A similar trend was also observed by Najm *et al.* (2010) who reported that the plant height increased linearly and very significantly in response to the application of organic manure and nitrogen inorganic fertilizer. Sharif *et al.* (2003) also reported that the highest plant height was 71.20 cm and lowest was 46.20 cm at 100 DAP when potato was grown with higher doses of cow dung + mustard oil cake (MOC) + N + P2O5 + K2O and without organic manure and inorganic fertilizers, respectively.

Due to combined effect of organic manures and inorganic fertilizer significantly influenced plant height at different days after planting (Table 1). The tallest plant (44.07cm) was observed at 75 days after planting (DAP) from F_3M_1 which was statistically similar to F_2M_1 (42.47 cm). On the other hand, the shortest plant (26.93) was recorded from F_0M_0 which was statistically similar to F_0M_1 (Table -1). The result from the treatment combination F_0M_2, F_0M_3, F_1M_0, F_1M_1, F_1M_2, F_1M_3, F_2M_0, F_2M_2, F_2M_3, F_3M_0, F_3M_2 and F_3M_3 should the intermediate level of plant height compared to other treatments combination.

Foliage coverage

In the present study, the foliage coverage was significantly influenced by the different inorganic fertilizer applications. At 60 DAP, the maximum foliage coverage (35.10%) was obtained from F3 (84.37 g. Urea + 50 g. TSP + 84.37 g. MOP) inorganic fertilizer application which showed significant difference among the other treatment. In contrast, the minimum foliage coverage (25.43%) was found from the control condition at 75 DAP. Similar trends of results were also reported at 45 and 60 DAP (Figure 2A). These results showed that the higher amount of urea, TSP and MOP gave the maximum amount of foliage coverage compare to other treatments. This might be due to nutrient availability induce the maximum vegetative growth as well as the maximum coverage percentage. The result of Hossain et al. (2011) was also similar with the present study where the foliage coverage varied significantly due to variation of inorganic fertilizer treatments and the higher inorganic fertilizer dose gives the higher foliage coverage.

A significant difference among the different organic manure on foliage coverage was observed (Appendix V). At 75 DAP, the maximum (32.83%) and the minimum (28.73%) foliage coverage were obtained from the treatment of M1 (4kg cowdung) and no organic manure uses, respectively (Fig. 2B). Similar performances of foliage coverage were also obtained at 45 and 60 DAP. These results indicated that cow dung was most efficient to increase the soil nutrient as well as higher fertility of the soil which might be increased the plant canopy and showed the maximum foliage coverage. So, the foliage coverage of potato plants showed a significant increase with the application of cow dung.

A significant variation was found due to the combined effect of organic manure and inorganic fertilizer application in respect of foliage coverage at different days after planting in the present study (Table 2). The maximum foliage coverage of potato plant (40.47%) was recorded in the treatment combination of F3M1 (84.37 g. Urea + 50 g. TSP + 84.37 g. MOP + 4 kg cowdung) which was significantly different from the other treatment combinations at 75 DAP. On the other hand, the control condition i.e., F0M0 produces the minimum foliage coverage (23.53%) at this stage.

Similarly, F_3M_1 recorded the maximum foliage coverage (39.20 and 39.80%) and in control condition gave the minimum foliage coverage (22.40 and 19.93%) at 45 and 60 DAP, respectively (Table 2). Larger tuber produced the early emergence and higher doses of cow dung increased the soil nutrient or fertility which increased the proper growth of potato canopy as well as the maximum foliage coverage was recorded with their combination.

Number of stem/hill

Number of stems per hill was significantly influenced due to application of inorganic fertilizer. The maximum number of stem $hill^{-1}$ was (5.98) from F_3 treatment which was followed by F_2 treatment (5.58) and the minimum number of stem $hill^{-1}$ (4.00) was recorded from control treatment (F_0) (Table. 3). These results indicated that the number of stems per hill increased significantly with the increased dose of inorganic fertilizer. This finding is in accordance with the observation of Ayoola and Makinde, (2007) and Al-Balikh (2008).

The number of stem hill^{-1} was found significant due to the effect of different organic manure applications. The maximum number of stem hill^{-1} (5.48) was produced from the treatment of M_1 (4 kg cowdung) while the minimum number of stem hill^{-1} (4.583) was observed in control or without organic manure treatment (Table 4). The number of main stems hill^{-1} in potato is generally related to the number of sprouts in a seed piece. Anand and Krishnappa (1988) reported that character is mainly dependent on the cultivars and physiological stage of the seed rather than the fertility of the soil.

Combined effect of different doses of organic manure and inorganic fertilizer was showed significant in respect of stems hill^{-1}. The maximum number of stems hill^{-1} (6.86) was found from the treatment combinations of F_3M_1 (84.37 g. Urea + 50 g. TSP + 84.37 g. MOP + 4 kg cow dung) which were significantly differed from the other treatment combination. In contrast, the minimum number of stem hill^{-1} (3.66) was recorded from the treatment combination of F_0M_0 which was closely similar to the treatment combination of F_0M_1 (Table 5). These results revealed that all the levels of cow dung significantly increased the number of stem hill^{-1} with the combinations of any size tuber.

Fresh weight of haulm

The fresh weight of stem is directly related to haulm growth of potato plant where inorganic fertilizer differ significantly in respect of fresh weight of haulm. Among the inorganic fertilizers, the highest fresh weight of haulm hill^{-1} (75.62 g) was found from while the lowest fresh weight of haulm hill^{-1} (56.64 g) was found from the no inorganic fertilizer doses (Table 3). These results indicated that the maximum inorganic fertilizer dose produces the maximum weight of haulm which was probably due to the higher growth of the stem, maximum leaves and a maximum number of stem.

The application of different organic manures also showed a significant difference in respect of the fresh weight of haulm. The highest weight of fresh haulm hill^{-1} (70.20 g) was observed in the treatment of M_1 (4 kg cowdung) and the minimum weight (64.21 g) was found when no organic manure was used (Table 4). Plant height and stem number directly related to the fresh weight of stem. In that case, cow dung produced the tallest plant, maximum stem and maximum leaves, resulting in the higher fresh weight of haulm were recorded. Najm *et al.* (2010) reported similar findings where higher doses of cow dung also recorded the higher fresh weight of shoots.

Fresh weight of haulm hill^{-1} also varied significantly by the combined effect of different levels of organic manures and inorganic fertilizer application. The highest weight of fresh haulm (82.62 g) was found from the treatment combinations of F_3M_1 (84.37 g. Urea + 50 g. TSP + 84.37 g. MOP + 4 kg cow dung) while the lowest weight of fresh haulm (55.29 g) was found from the no fertilizer treatment (Table 5)

Dry weight of haulm

Due to applications of different doses of inorganic fertilizers significantly influenced the dry weight of haulm at harvest. The higher weight of dry haulm hill^{-1} (9.17 g) was observed in the F_3 inorganic fertilizer dose (84.37 g. Urea + 50 g. TSP + 84.37 g. MOP) while the lowest (7.21 g) was found from without organic manure application (Table 4).

The variation of dry weight of haulm hill^{-1} among the different organic manures application was significant at harvest. The maximum weight of dry haulm hill^{-1} (8.68 g) was recorded from the treatment of M_1 (4 kg cowdung) and the lowest weight of dry haulm hill^{-1} (7.86) was found in control condition (Table 3). Najm *et al.* (2010) reported the doses of cow dung recorded the higher dry weight of shoots.

Significant variation was also observed from the combined effect of organic manures and inorganic fertilizers application at harvest . The highest weight of dry haulm hill^{-1} (10.09 g) was recorded from the treatment combinations of F_3M_1 (84.37 g. Urea + 50 g. TSP + 84.37 g. MOP + 4 kg cowdung). Whereas, the lowest weight of dry haulm hill^{-1} (6.92 g) was recorded from the control condition (Table 5).

Number of tubers per plot

Different doses of inorganic fertilizers significantly influenced the number of tubers plot^{-1}. Among the inorganic fertilizers, F_3 treatment (84.37 g. Urea + 50 g. TSP + 84.37 g. MOP) produced the maximum number of tubers plot^{-1} (203.00) which was significantly higher (195.2) than F_2 treatment (67.5 kg Urea + 40.5 g. TSP + 67.5 g. MOP) and the lowest (155.3) observed in control condition (Table 3). These results showed that the production of the number of tubers plot^{-1} increase with the increasing organic manure. The result of the present study is similar to Hossain *et al.* (2011). They observed that the number of stems plot^{-1} varied significantly due to variation of tuber size where significantly decreased stems hill^{-1}with decrease the tuber weight. Similar results were also reported by Sultana *et al.* (1991), Islam *et al.* (2001) and many other scientists.

Various organic manures significantly influenced the number of tuber production plot^{-1}. The maximum number of tuber plot^{-1}(191.1) was obtained from the M_1 (4kg cowdung) treatment and without organic manure application produced the minimum number of tubers (170.3) (Table 4). These results revealed that the number of tubers production significantly increased with the increasing level of cow dung. The higher doses of cow dung increased the physiological and chemical properties of the soil and further soils decomposed which contribute significantly increase the number of the tuber.

The combined effect of organic manure and inorganic fertilizer was found to be significant in respect of the number of tubers plot^{-1}. The maximum number of tubers plot^{-1} (227.7) was counted from the treatment combination of the F_3M_1 (84.37 g. Urea + 50 g. TSP + 84.37 g. MOP + 4 kg cowdung) which was statistically different from the other treatment combinations. On the other hand, the lowest number of tubers plot^{-1}(146.7) was observed from the treatment of no fertilizer (Table 5).

Scab percentage

Significant variation was found due to the application of different inorganic fertilizers. Among the inorganic fertilizer application, the highest scab (1.23%) was found without inorganic fertilizer treatment and then it decreased with the increasing of combined inorganic fertilizer effect. As a result, F_3 treatment (84.37 g. Urea + 50 g. TSP + 84.37 g. MOP) produced the lowest scab (0.40 %) (Table 3). The lowest scab percentage recorded the higher marketable yield as well as higher economic return in that case F_3 treatment (84.37 g. Urea + 50 g. TSP + 84.37 g. MOP) recorded the best results in respect of scab percentage.

Scab percentage also showed significant differences due to the effects of different organic manures. The highest scab (0.91%) and the lowest scab (0.71% and 0.70) were obtained from the control condition and M_2 (1.35 kg poultry dropping) and M_1 (4kg cowdung), respectively (Table 4). These results also revealed that the scab percentage significantly decreased with the different inorganic fertilizer applications which enhanced the higher marketable yield.

The combined effects of different inorganic fertilizers application was significantly influenced the scab percentage and their treatment combination also differ with each other among the all treatments (Table 5). The minimum scab (0.28% and 0.31%) was found from the treatment combination of the F_3M_1 (312.5 kg ha^{-1} Urea + 187.5 kg ha^{-1} TSP + 312.5 kg ha^{-1} MOP + 4 kg cowdung) and F_2M_1 (250 kg ha^{-1} Urea + 150 kg ha^{-1} TSP + 250 kg ha^{-1} MOP + 4 kg cowdung) while in control condition performed the higher scab (1.37%). The lower scab percentages reduce the yield loss and increase the marketable yield in that case F_3M_1 (312.5 kg ha^{-1} Urea + 187.5 kg ha^{-1} TSP + 312.5 kg ha^{-1} MOP + 4 kg cow dung) produce better results for the scab percentage of potato.

Gross yield and Marketable yield

A significant variation was also observed due to the combined effect of different organic manure and inorganic fertilizer application in respect of gross and marketable yield. The treatment combinations of the F_3M_1 (84.37 g. Urea + 50 g. TSP + 84.37 g. MOP + 4 kg cowdung) recorded the maximum gross and marketable yield (43.15 t ha^{-1} & 43.03 t ha^{-1}, respectively) while the minimum gross yield was found from the treatment combinations of F_0M_0.

Cost and return analysis

The economic analysis was done and the comparative benefit – cost ratio (BCR) of potato cultivation as influenced by organic manures and inorganic fertilizers was observed. The input and overhead costs were recorded for all the treatments and calculated on ha^{-1} basis. Variation in cost of production was noticed due to the cost of organic manure and different doses of inorganic fertilizer as per treatment. The total cost of production ranged between Tk. 79032.00 to 109210.13 where the maximum cost of production (Tk. 109210.13) was needed when MOC and maximum dose of inorganic fertilizer was used. Similarly, the lowest cost of production (79032.00) was required when no inorganic fertilizer and organic manure were used. The highest gross return (Tk. 602420) was obtained from the plot where cow dung and the highest doge of inorganic fertilizer was used because the higher marketable yield was recorded and the lowest gross return (Tk. 202860) was observed in the treatment combination of no organic manure and no inorganic fertilizer due to its lower marketable yield.

On the basis of the gross return, it was observed that the highest net return (Tk. 506946.13) was obtained with the treatment combination cowdung and the highest inorganic fertilizer dose was used. Similarly, the lowest net return (Tk. 123828.00) was found from the combination of no organic manure and no inorganic fertilizer was used. But the lowest benefit-cost ratio (1.35) was found in the combination of no organic manure and the lowest inorganic fertilizer dose. On the other hand, the highest BCR (5.31) was found from the treatment combination of F_3 (84.37 g. Urea + 50 g. TSP + 84.37 g. MOP) with M_1 (4 kg cow dung).

From the economic point of view, the above result indicated that the use of cowdung and higher doses of inorganic fertilizer was more profitable than other treatment combinations because of higher marketable yield, maximum gross and net return achieved here.

From the above results, it was concluded that the cowdung and the highest inorganic fertilizer alone or their combinations recorded the best results on the basis of growth, yield and yield contributing characters and also on economic analysis. As a result, tallest plant, maximum leaf $plant^{-1}$, stem and tubers $hill^{-1}$, higher fresh and dry weight of haulm, fresh weight of tuber as well as the maximum gross and marketable yield including higher gross and net return achieved from this treatment combination (312.5 kg ha^{-1} Urea + 187.5 kg ha^{-1} TSP + 312.5 kg ha^{-1}MOP + cow dung @ 15 t ha^{-1}). So, among the treatment, it was found that the highest dose of inorganic fertilizer was most advantageous and cow dung was an appropriate level for potato cultivation and their combination also better for maximum yield and higher net return of potato.

ACKNOWLEDGMENTS

The authors express their gratefulness and respect to the teachers and technical staff of the Horticulture department, PSTU and Horticulture Research Center (HRC), Lebukhali, Patuakhali for their co-operation in carrying out the research work.

Conflict of interests

The authors declare no conflict of interest among them.

REFERENCES

1. Adeyem, M-O, Fakore, M.A. and Edema, A.O. (1987). Effect of poultry Manure and cutting height on the performance of Amaranthushybridus. *Nigerian Journal of Agronomy*, *II (1)*: 12–20.
2. Ahmed, M. (2004). Effect of cow dung, boron and sulphur on the growth and yield of potato. MS Thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh. P. 81.
3. Ajari, O. Tsado Lek, Oladiran, J.A. and Salako, E.A. (2003). Plant height and fruit yield of okra as affected by field application of fertilizer and benlate in bida, Nigeria. *Nigeria Agricultural Journal, 34*: 74-80. DOI: 10.4314/naj.v34i1.3173
4. Al-Balikh K. (2008). The Influence of Kind and Quantity of Manure on Productivity and Quality Characteristics for Spring Potato in Raqqa Province Raqqa Research Center Alfurat University, Faculty of Agriculture.

5. Ali, M.R. costa, D.J. abedi, M.J. sayed, M.A. and Basak, N.C. (2009). Effect of fertilizer and variety on the yield of sweet potato. *Bangladesh Journal of Agricultural Research, 34(3):* 473-480.
6. Alva, A. (2004). Potato nitrogen management and organic matter in Bida, Nigeria. *The Nigerian Agricultural Journal, 34:* 74 – 80.
7. Anand, S. and Krishnappa, K.S. (1988). Effect of different levels of N and K on the growth, yield and quality of potato in sandy loam soil. Mysore, *Journal of Agricultural Science, 22(4):* 483–488.
8. Anonymous. (1997). Fertilizer Recommendation Guide. Bangladesh Agricultural Research Council, Farmgate, New Airport Road, Dhaka-1215. p22.
9. Anonymous. (2010). Salt stress new: Focus on form. Retrieved from http://www.armansabz.adinehgroup.com.
10. BBS. (2007). Annual Agricultural Statistics, December, 2007. Bangladesh Bureau of Statistics, Statistic Division, Ministry of Planning, Government People 's Republic of Bangladesh, Dhaka, p.137.
11. BBS. (2009). Statistical Year Book of Bangladesh. Statistic Division, Ministry of Planning, Government People's Republic of Bangladesh, Dhaka, p.141.
12. Bélanger, G. Walsh, J.R. Richards, J.E. Milburn, P.H. Ziadi, N. (2002). Nitrogen fertilization and irrigation affects tuber characteristics of two potato cultivars. *American Journal of Potato Research, 79:* 269-279.
13. Errebhi, M. Rosen, C.J. Gupta, S.C. Birong, D.E. (1998). Potato Yield Response and Nitrate Leaching as Influenced by Nitrogen Management. *Agronomy Journal, 90:*10–15.
14. FAO. (2002). Production Year book. Food and Agriculture Organization of the United Nations. Rome. Pp. 121-123.
15. Hashem, A. (1990). An Introduction to the Potato Seed Industry of Bangladesh. In: Seed Potato in Bangladesh. Proc. Int. Seminar on Seed Potato. BADC, Dhaka, Bangladesh, p.1–15.
16. Hassanpanah, D. Jafar, A. (2012). Evaluation of 'Out Salt' anti-stress material effects on mini-tuber production of potato cultivars under in vivo condition. *Journal of Food, Agriculture & Environment, 10 (1)*: 2 5 6 - 2 5 9.
17. Hossain, M.S. Zakaria, M. Hossain, M.M. and Rashid, M.H. (2011). Effect of Seed Size and Cutting Methods on the Yield and Profitability of Potato. *The Agriculturists, 9(1&2):* 54–62.
18. Islam, F. Rashid, M.H. Siddique, M.A. and Karim, M.R. (2001). Effect of seed size and spacing of seedling tubers from TPS on the growth and yield of potato. *Bangladesh Horticulture, 21(2)*: 25–30.
19. Kandil, A.A. Attia, A.N. Badawi, M.A. Sharief, A.E. Abido, W.A.H. (2011). Effect of Water Stress and Fertilization with Inorganic Nitrogen and Organic Chicken Manure on Yield and Yield Components of Potato. *Australian Journal of Basic and Applied Sciences, 5(9):* 997-1005.
20. Kara, K. (2002). The effects of nitrogen and phosphorus applications in various planting time and at different doses on quality. 3th National Potato Congress, 23–27 September 2002, İzmir, Turkey, pp.: 347-363.
21. Khandaker, M. M. Rohani, F. Dalorima, T. Mat, N. (2017). Effects of Different Organic Fertilizers on Growth, Yield and Quality of Capsicum Annuum L. Var. Kulai (Red Chilli Kulai). *Biosci Biotech Res Asia, 14(1).*
22. Leytem, A.B. Westermann, D.T. (2005). Phosphorus availability to barley from manures and fertilizers on a calcareous soil. *Soil Science. 170(6):*401-412.
23. Najm, A.A. Haj, S.H.M.R. Fazeli, F. Darzi, M. and Shamorady, R. (2010). Effect of Utilization of Organic and Inorganic Nitrogen Source on the Potato Shoots Dry Matter, Leaf Area Index and Plant Height, During Middle Stage of Growth. *International Journal of Agricultural & Biological Science, 1(1):* 26–29.
24. Najm, A.A. Seyed, H.M.R.H. Fazeli, F. Darzi, M.T. and Rahi, T. (2012). Effect of Integrated Management of Nitrogen Fertilizer and Cattle Manure on the Leaf Chlorophyll, Yield, and Tuber Glycoalkaloids of Agria Potato. *Journal of Communications in Soil Science & Plant Analysis, 43(5–8):* 912–923.
25. Rashid, M.M. Rashid, M.H. and Sarkar, M.H. (1987). Yield Potential of Exotic Potato Varieties in Bangladesh. Res. Bull. PRC, BARI, Joydebpur, Gazipur. P.1–11.

26. Ruiz, J. Hernandez, M.J. Castilla, N. Romero, L. (1999). Potato performance in response to Different Mulches. 1. Nitrogen Metabolism and yield. *Journal of agriculture and food chemistry, 47,* 2660-2665.
27. Russell, D.F. (1986). MSTAT–C computer based data analysis software). Crop and Soil Science Department, Michigan State University, USA.
28. Semiha, G. (2009). Effects of nitrogen on yield and chlorophyll of potato (Solanumtuberosum L.) cultivars. *Bangladesh Journal of Botany, 38(2):* 163-169.
29. Sharif, H.A.B.M. Hakim, M.A. and Onguso, J.M. (2003). Effect of Manure and Fertilizers on the Growth and Yield of Potato. *Pakistan Journal of Biological Science, 6:* 1243–1246.
30. Sultana, N. and Siddique, M.A. (1991). Effects of cut seed piece and plant spacing on the yield and profitability of potato. *Bangladesh* Horticulture, 17(1): 37–43.
31. White, P.J. Wheatley, R.E. Hammond, J.P. Zhang, K. (2007).Minerals, soils and roots. In: Vreugdenhil D (ed) Potato biology and biotechnology, advances and perspectives. Elsevier, Amsterdam, pp.: 739-752.
32. Zebarth, B.J. Leclerc, Y. Moreau, G. Botha, E. (2004). Rate and timing fertilization of Russet Burbank potato: yield and processing quality. *Canadian Journal of Plant Science, 84:* 855-863.
33. Zelalem, A. Tekalign, T. Nigussie, D. (2009).Response of potato (*Solanum tuberosum* L.) to different rates of nitrogen and phosphorus fertilization on vertisols at Debre Berhan, in the central highlands of Ethiopia. *African Journal of Plant Science, 3*: 16-24.

Table 1. Combined effect of different inorganic fertilizer application on plant height at different days after planting (DAP) of potato plant

Treatments	Treatments	Plant height(cm) at different DAP		
		45	60	75
F_0	M_0	24.13 l	25.73 k	26.93 j
F_0	M_1	26.00 k	28.47 j	28.93 ij
F_0	M_2	27.80 j	29.87 ij	31.60 hi
F_0	M_3	28.27 ij	31.53 hi	33.20 gh
F_1	M_0	29.73 hi	33.47 gh	35.07 fg
F_1	M_1	30.33 gh	34.53 fg	35.80 e-g
F_1	M_2	30.93 f-h	35.40 e-g	36.80 d-f
F_1	M_3	31.27 f-h	36.07 d-g	37.87 d-f
F_2	M_0	31.73 e-g	36.53 d-f	38.20 c-f
F_2	M_1	36.27 ab	41.00 ab	42.47 ab
F_2	M_2	34.53 b-d	38.47 b-d	40.07 b-d
F_2	M_3	32.73 d-f	36.87 d-f	38.47 c-f
F_3	M_0	33.13 c-e	37.60 c-e	38.80 c-e
F_3	M_1	36.80 a	41.93 a	44.07 a
F_3	M_2	34.87 bc	40.07 a-c	41.47 a-c
F_3	M_3	34.07 cd	38.27 cd	39.47 b-d
LSD $_{(0.05)}$		1.669	2.415	3.026
CV (%)		3.19	4.10	4.93

Values having same letter(s) within the column do not differ significantly at 5% level of probability analyzed by DMRT.

F_0 = No fertilizer (Control), F1 = 50 g. Urea + 31 g. TSP + 50 g. MOP, F_2 = 67.5 kg Urea + 40.5 g. TSP +67.5 g. MOP, F_3 = 84.37 g. Urea+50 g. TSP +84.37 g. MOP; M0 = No manure (Control),M1 = 4 kg cowdung, M2 = 1.35 kg poultry dropping, M3 = 1/2 kg MOC (Mustard oil Cake).

Table 2. Combined effect of different inorganic fertilizer application foliage coverage (%) at different days after planting (DAP) of potato plant

Treatments	Treatment	Foliage coverage(%) at different DAP		
		45	60	75
F_0	M_0	19.93 l	22.40 k	23.53 k
F_0	M_1	20.73 kl	23.80 jk	25.07 jk
F_0	M_2	22.60 jk	25.13 ij	26.40 ij
F_0	M_3	23.60 j	25.80 h-j	26.73 ij
F_1	M_0	24.80 ij	26.67 g-i	28.27 hi
F_1	M_1	26.40 hi	27.80 f-h	29.13 gh
F_1	M_2	27.20 gh	28.20 fg	29.67 gh
F_1	M_3	28.13 gh	28.27 fg	29.80 f-h
F_2	M_0	28.93 fg	29.73 ef	31.00 e-g
F_2	M_1	36.73 b	35.20 b	36.67 b
F_2	M_2	34.33 cd	32.67 cd	33.87 cd
F_2	M_3	29.40 fg	30.60 de	31.87 d-f
F_3	M_0	31.13 ef	30.87 de	32.13 de
F_3	M_1	39.80 a	39.20 a	40.47 a
F_3	M_2	34.87 bc	33.80 bc	35.00 bc
F_3	M_3	32.27 de	31.53 de	32.80 de
LSD $Value_{0.05}$		2.116	1.988	2.000
CV (%)		4.41	4.04	3.90

Values having same letter(s) within the column do not differ significantly at 5% level of probability analyzed by DMRT.

F_0 = No fertilizer (Control), F1 = 50 g. Urea + 31 g. TSP + 50 g. MOP, F_2 = 67.5 kg Urea + 40.5 g. TSP +67.5 g. MOP, F_3 = 84.37 g. Urea+50 g. TSP +84.37 g. MOP; M0 = No manure (Control),M1 = 4 kg cowdung, M2 = 1.35 kg poultry dropping, M3 = 1/2 kg MOC (Mustard oil Cake).

Table 3. Effects of inorganic fertilizer on number of stem/hill, number of tuber/plot, fresh weight of haulm, dry weight of haulm and scab % at harvest of potato plant

Treatments	Stem/hill	fresh weight of haulm (g)	dry weight of haulm (g)	Tuber /plot	scab %
F_0	4.00 d	56.64 d	7.21 d	155.3 d	1.23 a
F_1	4.65 c	64.23 c	7.92 c	169.8 c	0.93 b
F_2	5.58 b	72.06 b	8.77 b	195.2 b	0.51 c
F_3	5.98 a	75.62 a	9.17 a	203.0 a	0.40 d
LSD Value $_{0.05}$	0.2790	0.4996	0.09506	4.812	0.02637
CV (%)	6.61	0.89	1.37	3.19	4.77

Values having same letter(s) within the column do not differ significantly at 5% level of probability analyzed by DMRT.

F_0 = No fertilizer (Control), F_1 = 50 g. Urea + 31 g. TSP + 50 g. MOP, F_2 = 67.5 kg Urea + 40.5 g. TSP +67.5 g. MOP, F_3 = 84.37 g. Urea+50 g. TSP +84.37 g. MOP

Table 4. Effects of organic manures on stem/hill, tuber/plot, fresh weight of haulm, dry weight of haulm and scab % at harvest of potato plant

Treatments	Stem/hill	fresh weight of haulm (g $plant^{-1}$)	dry weight of haulm(g $plant^{-1}$)	Tuber / plot	scab %
M_0	4.583 c	64.21 d	7.866 d	170.3 c	0.9167 a
M_1	5.483 a	70.20 a	8.680 a	191.1 a	0.7083 c
M_2	5.217 a	67.61 b	8.379 b	182.8 b	0.7100 c
M_3	4.933 b	66.54 c	8.167 c	179.0 b	0.7542 b
$LSDValue_{0.05}$	0.2790	0.4996	0.09506	4.812	0.02637
% CV	6.61%	0.89%	1.37%	3.19%	4.77%

Values having same letter(s) within the column do not differ significantly at 5% level of probability analyzed by DMRT.

M_0 = No manure (Control), M_1 = 4 kg cowdung, M_2 = 1.35 kg poultry dropping, M_3 = 1/2 kg MOC (Mustard oil Cake)

Table 5. Combined effect of different organic manures and inorganic fertilizer application on stem/hill, tuber/plot, fresh weight of haulm, dry weight of haulm and scab % at harvest of potato plant

Treatments	Treatments	Stem/hill	fresh weight of haulm	dry weight of haulm	Tuber /plot	scab %
F_0	M_0	3.66 k	55.29 l	6.92 l	146.7 k	1.37 a
F_0	M_1	3.80 jk	56.40 k	7.19 k	154.7 jk	1.26 b
F_0	M_2	4.20 i-k	56.85 k	7.32 jk	158.7 ij	1.16 c
F_0	M_3	4.33 h-j	58.04 j	7.44 j	161.3 ij	1.13 c
F_1	M_0	4.40 h-j	62.65 i	7.67 i	163.0 h-j	1.06 d
F_1	M_1	4.66 g-i	63.15 i	7.92 h	168.7 g-i	0.98 e
F_1	M_2	4.73 g-i	64.40 h	7.96 h	172.0 f-h	0.88 f
F_1	M_3	4.80 f-i	66.74 g	8.11 gh	175.3 fg	0.81 g
F_2	M_0	4.86 e-h	67.35 g	8.24 fg	182.0 ef	0.72 h
F_2	M_1	6.60 ab	78.62 b	9.51 b	213.3 b	0.31 m
F_2	M_2	5.73 cd	73.34 d	8.96 d	198.3 cd	0.42 kl
F_2	M_3	5.13 d-g	68.93 f	8.39 f	187.0 e	0.61 i
F_3	M_0	5.40 d-f	71.56 e	8.63 e	189.7 de	0.51 j
F_3	M_1	6.86 a	82.62 a	10.09 a	227.7 a	0.28 m
F_3	M_2	6.20 bc	75.86 c	9.26 c	202.3 c	0.37 l
F_3	M_3	5.46 de	72.46 de	8.72 e	192.3cde	0.45 k
$LSD\ Value_{0.05}$		0.5581	0.9991	0.1901	9.623	0.05273
CV (%)		6.61	0.89	1.37	3.19	4.77

Values having same letter(s) within the column do not differ significantly at 5% level of probability analyzed by DMRT.

F_0 = No fertilizer (Control), F1 = 50 g. Urea + 31 g. TSP + 50 g. MOP, F_2 = 67.5 kg Urea + 40.5 g. TSP +67.5 g. MOP,

F_3 = 84.37 g. Urea+50 g. TSP +84.37 g. MOP; M0 = No manure (Control),M1 = 4 kg cowdung, M2 = 1.35 kg poultry dropping, M3 = 1/2 kg MOC (Mustard oil Cake).

Table 6. Combined effect of different organic manures and inorganic fertilizer application the gross and marketable yield of potato

Treatments	Treatments	Gross yield of tubers		Marketable yield of tubers	
		(kg/plot)	(ton/ha)	(kg/plot)	(ton/ha)
F_0	M_0	3.96 l	14.69 l	3.91 l	14.49 l
F_0	M_1	4.22 l	15.65 l	4.17 l	15.45 l
F_0	M_2	4.54 kl	16.82 kl	4.48 kl	16.63 kl
F_0	M_3	5.21 jk	19.32 jk	5.15 jk	19.10 jk
F_1	M_0	5.66 ij	20.99 ij	5.60 ij	20.76 ij
F_1	M_1	6.02 h-j	22.31 h-j	5.96 h-j	22.10 h-j
F_1	M_2	6.46 g-i	23.95 g-i	6.41 g-i	23.74 g-i
F_1	M_3	6.73 f-h	24.94 f-h	6.67 f-h	24.73 f-h
F_2	M_0	6.84 f-h	25.34 f-h	6.79 f-h	25.16 f-h
F_2	M_1	9.35 b	34.63 b	9.32 b	34.52 b
F_2	M_2	8.21 cd	30.43 cd	8.18 cd	30.30 cd
F_2	M_3	7.26 e-g	26.91 e-g	7.22 e-g	26.75 e-g
F_3	M_0	7.41 d-f	27.47 d-f	7.37 d-f	27.33 d-f
F_3	M_1	11.65 a	43.15 a	11.62 a	43.03 a
F_3	M_2	8.61 bc	31.91 bc	8.58 bc	31.79 bc
F_3	M_3	7.75 c-e	28.70 c-e	7.71 c-e	28.57 c-e
LSD $Value_{0.05}$		0.8338	3.086	0.8287	3.068
CV (%)		7.27	7.27	7.28	7.28

Values having same letter(s) within the column do not differ significantly at 5% level of probability analyzed by DMRT.

F_0 = No fertilizer (Control), F1 = 50 g. Urea + 31 g. TSP + 50 g. MOP, F_2 = 67.5 kg Urea + 40.5 g. TSP +67.5 g. MOP,

F_3 = 84.37 g. Urea+50 g. TSP +84.37 g. MOP; M0 = No manure (Control),M1 = 4 kg cowdung, M2 = 1.35 kg poultry dropping, M3 = 1/2 kg MOC (Mustard oil Cake).

Table 7. Cost and return analysis of potato considering organic manure and inorganic fertilizer application

Inorganic fertilizers	Organic manures	Marketable yield (t ha^{-1})	Total cost of production (Tk. ha^{-1})	Gross return (Tk. ha^{-1})	Net return (Tk. ha^{-1})	Benefit cost ratio (BCR)
F_0	M_0	14.49	79032.00	202860.00	123828.00	1.57
F_0	M_1	15.45	92143.88	216300.00	124156.13	1.35
F_0	M_2	16.63	96514.50	232820.00	136305.50	1.41
F_0	M_3	19.10	100885.13	267400.00	166514.88	1.65
F_1	M_0	20.76	87357.00	290640.00	203283.00	2.33
F_1	M_1	22.10	100468.88	309400.00	208931.13	2.08
F_1	M_2	23.74	104839.50	332360.00	227520.50	2.17
F_1	M_3	24.73	104215.13	399980.00	295764.88	2.84
F_2	M_0	25.16	83194.50	352240.00	269045.50	3.23
F_2	M_1	34.52	96306.38	483280.00	386973.63	4.02
F_2	M_2	30.30	100677.00	424200.00	323523.00	3.21
F_2	M_3	26.75	96306.38	374500.00	278193.63	2.89
F_3	M_0	27.33	82362.00	382620.00	300258.00	3.65
F_3	M_1	43.03	95473.88	602420.00	506946.13	5.31
F_3	M_2	31.79	99844.50	445060.00	345215.50	3.46
F_3	M_3	28.57	109210.13	346220.00	237009.88	2.17

F_0 = No fertilizer (Control), F1 = 50 g. Urea + 31 g. TSP + 50 g. MOP, F_2 = 67.5 kg Urea + 40.5 g. TSP +67.5 g. MOP, F_3 = 84.37 g. Urea+50 g. TSP +84.37 g. MOP; M0 = No manure (Control),M1 = 4 kg cowdung, M2 = 1.35 kg poultry dropping, M3 = 1/2 kg MOC (Mustard oil Cake).

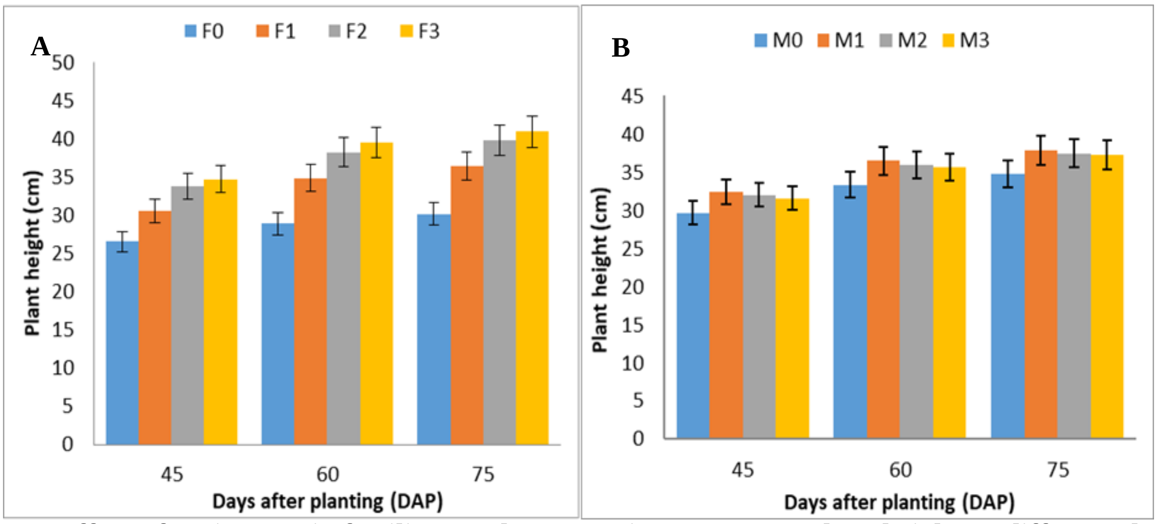

Fig.1. Effect of A. inorganic fertilizer and B. organic manure on plant height at different days after planting (DAP). The vertical bars represent the LSD at 5% level of probability.

F_0 = No fertilizer (Control), F1 = 50 g. Urea + 31 g. TSP + 50 g. MOP, F_2 = 67.5 kg Urea + 40.5 g. TSP +67.5 g. MOP, F_3 = 84.37 g. Urea+50 g. TSP +84.37 g. MOP; M0 = No manure (Control), M1 = 4 kg cowdung, M2 = 1.35 kg poultry dropping, M3 = 1/2 kg MOC (Mustard oil Cake).

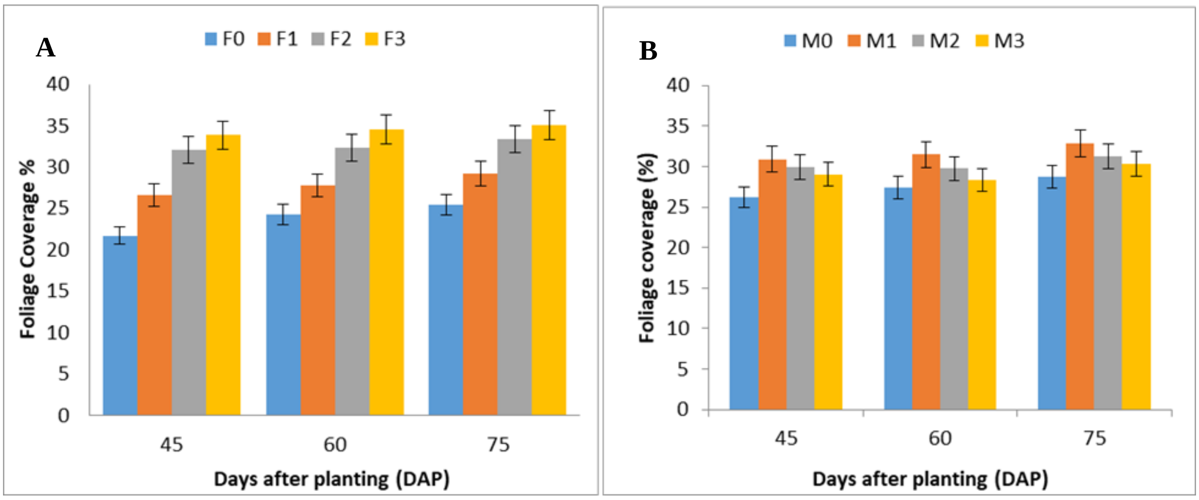

Fig.2. Effect of A. inorganic fertilizer and B. organic manures on foliage coverage at different days after planting (DAP). The vertical bars represent the LSD at 5% level of probability

F_0 = No fertilizer (Control), F1 = 50 g. Urea + 31 g. TSP + 50 g. MOP, F_2 = 67.5 kg Urea + 40.5 g. TSP +67.5 g. MOP, F_3 = 84.37 g. Urea+50 g. TSP +84.37 g. MOP; M0 = No manure (Control),M1 = 4 kg cowdung, M2 = 1.35 kg poultry dropping, M3 = 1/2 kg MOC (Mustard oil Cake).