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Effect of Previous Crops and Fertilizers Management of Stem Amaranth in Vegetables – Vegetables - Rice Cropping System

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SP and MZ designed the conceptual framework of study, performed relevant literature search and wrote the initial draft of the manuscript. Author MAS drawn the pictures and assisted in the formulation of tabular constituents. Authors M. M. Hossain and M. M. Haque reviewed and rewrote the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To determine the effect of previous crops and fertilizers management on yield and yield parameters of stem amaranth (*Amaranthus tricolor* L.) in vegetables-vegetables-rice cropping system.

Study Design: A randomized complete block design (RCBD) with six treatment combinations having four replications was used for the experiment.

Place and Duration of Study: The field experiment was conducted in kharif-1 seasons (April to June) 2018 and 2019 at the research field of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh.

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Methodology: The layout was kept undisturbed for the cropping sequence over two years. Factor-A had three previous crops under the cropping system as P1= Potato (Potato - Stem Amaranth - T. Aman rice), P2= Garlic (Garlic -Stem Amaranth -T. Aman rice), P3= Cauliflower (Cauliflower -Stem Amaranth - T. Aman rice) and Factor-B had two level of fertilizers management as F1= Organic fertilizer (N based organic compost), F2= Inorganic fertilizer (Estimated inorganic fertilizer dose based on the soil test value without cow dung). The data were recorded on plant height, leaves per plant, stem diameter, stem yield (t ha^{-1}) and stem dry matter content (%) during harvesting time.

Results: Significantly maximum plant height was observed (93.5cm) in inorganic fertilizer treated plot under previous crop cauliflower which was followed by (93.0cm and 75.0cm) under garlic and potato, respectively. Whereas, minimum plant height (61.8cm) receiving organic source of fertilizers when the previous crop was potato in 2019. The interaction of previous crops and fertilizer application showed significant variation on leaves per plant of stem amaranth both in 2018 and 2019. Stem diameter showed the same trend as that of stem dry matter and resulted insignificant influence due to previous crops and fertilizers management over the two years. In 2018, significantly higher stem yield was observed (38 t ha^{-1}) in inorganic fertilizer treated plot under previous crop cauliflower which was followed by (36.1 t $ha^{-1}$and 35.5 t ha^{-1}) under garlic and potato, respectively. Whereas, lower stem yield (20.0 t ha^{-1}) receiving inorganic source of fertilizers when the previous crop was cauliflower. Higher stem yield was observed (51.4 t ha^{-1}) in (F2P2) treated plot which was followed by (44 t ha^{-1}) under F2P3 and F2P1, respectively. Whereas, lower stem yield (22.0 t ha^{-1}) receiving F1 source of fertilizers when the previous crop was P3 in 2019.

Conclusion: The experimental results of this study have shown that previous crops had a positive impact on the yield parameters of stem amaranth like plant height in 2018 and leaf numbers of plant both in 2018 and 2019. Interaction effect of previous crops and fertilizers management exerted significant variations only on leaves per plant of amaranth both in 2018 and 2019. Moreover, fertilizers management showed significant variation for plant height in 2019 and for stem yield both in 2018 and 2019.Therefore, it was concluded that stem amaranth after previous crop garlic with soil test based inorganic fertilizer could be high yielding and N based organic compost could be moderate yielding under Garlic- Amaranth – T. Aman cropping system.

Keywords: Previous crops; stem amaranth; organic compost; inorganic fertilizer; yield; yield parameters.

1. INTRODUCTION

Stem amaranth (*Amaranthus tricolor* L.) belongs to the genus *Amaranthus* of the family Amaranthaceae and is locally known as danta. Amaranth is considered as one of the nutritious and delicious vegetables in Bangladesh because of its cheap price, quick growing character and higher yield potential. It is also, considered as a potential upcoming subsidiary food crop for future generation [1]. The most dominant vegetable cropping pattern is vegetable-vegetable - vegetable in Bangladesh covered 1.67% of net cropped area where as vegetable - vegetable - T. Aman is about 1% of net cropped area of Bangladesh [2]. It is generally grown after rabi crops and after harvesting amaranth, T. Aman is grown easily. Winter rabi crops based rotations for numerous kharif - crops are available under the vegetables – rice based cropping system but little information exists on better preceding rabi crops for (kharif-1) stem amaranth in Bangladesh. There is a serious scarcity of vegetables during the months of May to September. At present amaranth is being cultivated in an area of 10772.47 hectare with a total production of 75146 tons. This average yield is only about 35-40 tons per hectare [3]. As the nation runs short of vegetables, stem amaranth can play a vital role in the increase of the total vegetable production in the country and it has also scope for export. Fifty-four kinds of different vegetables were exported from Bangladesh and amaranth (Danta) is one of them. The importing countries were mostly in the Middle East. The demand for summer vegetables was found higher than those of winter vegetables [4].

Until recently most of the research work has been mainly confined to the nutrient requirement of an individual crop and fertilizer recommendation made on the basis of fertilizer response data of a single crop without taking into consideration the effect of preceding crop and soil test value. Now it is increasingly realized that when crops are grown in system, the fertilizer needs of an individual crop cannot be precisely determined without taking into account the nature of preceding crop, it’s yield level and residual effect of fertilizer application [5]. Amaranth requires high soil fertility for rapid growth in a short time. It responds greatly to major essential elements like N, P and K for its growth and yield [6]. Meanwhile, nitrogen is the most crucial input for increasing crop production and has been recognized as the central element for agricultural production. Organic manure is a good source of nutrients, especially N, P & S and it's a good means of soil rejuvenation [7]. So, use of OM could be an inevitable practice in the coming years for ensuring sustainable crop productivity without affecting soil fertility [8-9]. As stated by [10], unbalanced use of chemical fertilizers has affected soil health, causing a substantial decrease in soil organic carbon. As a general rule, use of organic fertilizers especially in composted form produces positive effect on soil health and fertility, which consequents increased crop yield on a long-term basis [11].

Several workers stated that application of inorganic fertilizer or organic compost increased yield of stem amaranth. But there is no available research information about the effect of previous rabi crops and fertilizer managements on yield of stem amaranth. Therefore, the objective of this study was to determine the effect of previous crops and fertilizers management on yield and yield parameters of tem amaranth in vegetables – vegetables - rice cropping system.

2. MATERIALS AND METHODS

2.1 Experimental Site and soil

The field experiment was conducted in kharif-1 seasons (April to June) 2018 and 2019, at the research field of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh, located at 24°09/ North Latitude and 90°26/ East Longitude with elevation of 8.2m from mean sea level. It belongs to Agro-Ecological Zone (AEZ-28) as Madhupur Tract. Data on monthly average temperature, relative humidity and rainfall for two years of study are shown in Table 1 and Table 2, respectively. The initial soil chemical properties at 0-15 cm soil depth had pH6.63, organic matter content 0.86%, total nitrogen (N) 0.07%, available phosphorus (P) 17 ppm, exchangeable potassium (K) 0.07 Cmol 100 g^{-1} soil, available sulfur (S) 9 ppm, available zinc (Zn) 0.8 ppm and available Boron (B) 0.10 ppm.

2.2 Experimental Design and Treatment

The experiment was set up in Randomized Complete Block (RCB) design with six treatment combinations having four replications. The unit plot size was 3.5 m x 3.5 m for crops having row to row distance 25 cm. The layout was kept undisturbed for the cropping sequence over two years. Factor-A had three previous crops under the cropping system as P1= Potato (Potato - Stem Amaranth - T. Aman rice), P2= Garlic (Garlic - Stem Amaranth -T. Aman rice), P3= Cauliflower (Cauliflower -Stem Amaranth - T. Aman rice) and Factor-B had two level of fertilizers management as F1= Organic fertilizer (N based organic compost), F2= Inorganic fertilizer (Estimated inorganic fertilizer dose based on the soil test value without cow dung).

2.3 Experimental Organic Fertilizer

The test organic fertilizer, ACI organic compost, used in the experiment was collected from a shop of Agro Chemical Industries (ACI). The chemical composition of the organic compost showed the concentrations of N as 1.35 ± 0.5%, P 1.8 ±0.1% and K 2.1 ± 0.2%, respectively (Average figure represents analytical results of 10 samples) in dry weight basis. The organic compost was applied as dry weight basis.

2.4 Previous Crops and test crop

The previous crops for three cropping system were potato, garlic and cauliflower, respectively. The test crop for all cropping system used in the experiments was a high yielding variety of Stem amaranth (cv. BARI danta-1) released by Bangladesh Agricultural Research Institute, (BARI) and its life cycle is 50 – 60 days (BARI, 2000).

Table 1. Mean monthly minimum and maximum air temperature for the experimental site during stem amaranth growing periods in 2018 and 2019

Months	Mean monthly air temperature (°C)			
	Minimum		Maximum	
	2018	2019	2018	2019
April	21.41	22.30	32.64	32.57
May	22.76	25.49	31.92	34.53
June	24.78	26.20	33.56	34.00

2.5 Field experiment

Sowing and harvest time of previous crops in two growing seasons as shown in Table 3. The land was prepared very well by deep and cross plowing with a tractor drawn disk and rotavator followed by laddering. The rates of organic and inorganic fertilizers were applied regarding to treatments for test crop as shown in Table 4. Organic compost was calculated based on N equivalence (117 kg ha^{-1} for amaranth) and applied on dry weight basis two weeks prior to planting. Based on the nutrient (NPKS) properties of initial soil, fertilizers rates were calculated using fertilizer recommendation guide of Bangladesh Agricultural Research Council [12]. For stem amaranth, $^1/_3$ amount of urea and other fertilizers were applied as basal. The rest of urea was applied into two equal splits: ½ as 15-20 DAS (Days after seeding) and the rest ½ at 40-45 DAS (Days after seeding). Seeds of stem amaranth (var. BARI Data 1) were sown in line with 25cm spacing and continuous seeding at a seed rate of 2.25 kg/ha during April ,2018-19. Necessary intercultural operations, irrigation, and plant protection measures were done as and when ever required for crop during the period of the experiment.

2.6 Data Collection and Determination

The crop was harvested 50 days after seed sowing. The data were recorded on plant height, leaves/plant, stem diameter, stem yield (t ha^{-1}), stem dry matter content (%) during harvesting time from ten randomly selected plants in each plot. Plant heights were measured from the surface of the ridge to the apex of the plants and then average height of 10 plants was finally calculated at harvest. Average number of leaves and diameter of stem were recorded from 10 plants. After harvesting, the yield of total stems per m^2 per plot were recorded in Kilograms separately and converted into t ha^{-1}. Stem dry matter content was determined on a composite, fresh sub-sample of stem of approximately 150 g taken from the different size stems after oven drying at 80 ± 2 ^{0}C for 72 hours and was calculated by dividing the dry weight of stems to the fresh weight stems and multiplied by 100.

2.7 Analysis of Soil Samples

Initial soil samples were analyzed for physical and chemical properties following standard methods. Organic matter was determined by Walkley and Black method [13], soil pH (1:2.5 soil-water) by glass electrode pH meter method [14], total N by Semi-micro Kjeldahl method [15], available P by Olsen method [16], exchangeable K by Flame Photometer after extraction with 1N NH_4OAC at pH7.0 [17], available S by extracting soil samples with $CaCl_2$, solution (0.15%) and by measuring turbidity by Spectrophotometer [18] method.

2.8 Statistical Analysis

The data were subjected to statistical analysis by using the software CropStat7.2 version to find out the significance of variation between treatments. The difference between the treatment means were judged by Duncan's Multiple Range Test (DMRT) according to [19].

Table 2. Mean monthly relative humidity and rainfall for the experimental site during stem amaranth growing periods in 2018 and 2019

Months	Relative humidity (%)		Rainfall (mm)	
	2018	2019	2018	2019
April	76.07	80.54	1.00	3.90
May	81.28	80.82	14.50	6.23
June	80.66	85.00	10.34	5.64

Table 3. Sowing and harvest time of previous rabi crops in two growing seasons (2018-2019)

Previous rabi crops	Sowing time	Harvesting time
Potato	25-30 November	1 - 4 March
Garlic	14 – 15 October	20 - 22 March
Cauliflower	12 – 15 September	25 – 30 December

Table 4. Rate of fertilizers applied for stem amaranth in vegetables – vegetables - rice cropping system, 2018 - 2019

	Nutrient (kg/ha)					
Treatment	**N**	**P**	**K**	**S**	**Zn**	**B**
CP1= Potato – Stem Amaranth - T. Aman rice						
F1	09 (ton/ha)					
F2	117	18	60	5	-	-
CP2= Garlic –Stem Amaranth - T. Aman						
F1	09 (ton/ha)					
F2	117	18	60	5	-	-
CP3= Cauliflower –Stem Amaranth - T. Aman						
F1	09 (ton/ha)					
F2	117	18	60	5	-	-

F_1= Organic fertilizer (N based organic compost) and F_2= Inorganic fertilizer (Estimated inorganic fertilizer dose based on the soil test value without cow dung)

3. RESULTS AND DISCUSSION

3.1 Plant Height

Plant height of stem amaranth demonstrated poor interaction effect of previous crops and fertilizer application in the amaranth both in 2018 and 2019. Previous crops had significant effect (P = .01) on plant height of stem amaranth in 2018 but not in 2019 Table 5. In 2018, fertilizer treatments showed no significant difference in amaranth height among all the cropping system in 2018 Fig. 1a. Amaranth produced taller plants (> 80cm) when the previous crop was garlic in cropping system(CP2) than the plants grown after potato in CP1. Stem height of amaranth was 65cm in organic fertilizer treated plot (F1) and 57cm in inorganic fertilizer treated plots (F2) where the previous crop was potato in CP Fig. 1a. In 2019, significant difference was observed on plant height between fertilizer treatments among all the previous crops. Maximum plant height was observed (93.5cm) in inorganic fertilizer (F2) treated plot under P3 which was followed by (93.0cm and 75.0cm) under F2P2 and F2P1, respectively. Whereas, minimum plant height (61.8cm) receiving F1 source of fertilizers when the previous crop was P1 Fig. 1b. As a results, plants grew well during the growing period in all of the treatments. However, the plant height ranged from (61.80 to 83.50) cm recorded in F1 and from (57.00 to 93.50) cm recorded in F2 for all the pre-crops over the two years indicating the dominant role of soil test based inorganic source of fertilizer on plant growth. More rapid growth of amaranth was realized with use of chemical fertilizer compared to compost. This could be due to increased availability of soil nitrogen with application of inorganic fertilizer culminating into enhanced N uptake and hence faster growth. Release of nitrogen by compost however occurs slowly after mineralization. These findings are in agreement with those of other researchers [20-22] who found that while nitrogen supplied by inorganic fertilizer was readily available, the nitrogen supplied by manure was released slowly. The plant height in different treatments varied possibly due to applied treatments effect.

3.2 Leaves Per Plant

The interaction of previous crops and fertilizer application showed significant effect (P = .01) on leaves per plant of stem amaranth both in 2018 and 2019.Similarly, previous crops had significant effect (P = .01) on leaves per plant of stem amaranth both in 2018 and 2019 Table 6. Significant difference was observed under all the previous crops on amaranth leaves per plant due to fertilizer treatments both in 2018 and 2019 Fig. 2a-b. In 2018, highest leaves per plant was observed (48.0) in inorganic fertilizer (F2) treated plot under P1 which was followed by (31.0 and 25.8) under F2P3 and F2P2, respectively. Whereas, lowest leaves per plant (21.8) receiving F1 source of fertilizers when the previous crop was cauliflower Fig. 2a. Similar trend was observed in leaves per plant due to fertilizer treatment under all the previous crops in 2019 Fig. 2b. The maximum number of leaves per plant was at soil test based inorganic fertilizer because there was fast release of nitrogen and other plant nutrients (phosphorus and potassium) than organic manures and available nitrogen was high at root zone. However, nitrogen initiated higher growth of stem and leaves of plant. Similar result was also found by [23-25] in their research with fertilizers (recommended dose) and manures.

3.3 Stem Diameter

Stem diameter of amaranth demonstrated poor significant effect by previous crops in the amaranth under all the Previous crops both in 2018 and 2019. However, interaction effect of previous crops and fertilizer application was not significant. Similarly, it was observed that stem diameter did not differ significantly due to fertilizer treatments both in 2018 and 2019 Table 7. In 2018, higher stem diameter was observed (18.5mm) in inorganic fertilizer (F2) treated plot which was followed by (17.8mm) under F2P3 and F2P2, respectively. Whereas, lower stem diameter (13.0mm) receiving F2 source of fertilizers when the previous crop was potato Fig. 3a. Similar trend was observed in stem diameter due to fertilizer treatment under all the previous crops in 2019 Fig. 3b. The stem diameter significantly affected by different levels of compost in combination with or without N-fertilizers [26]. The stem diameter in different treatments varied possibly due to applied treatments effect.

3.4 Stem Dry Matter

Stem dry matter of amaranth showed insignificant interaction effect of previous crops and fertilizer application in the current amaranth both in 2018 and 2019. However, stem dry matter of amaranth was not affected by the previous crops Table 8. Similarly, it was observed that stem dry matter did not differ significantly due to fertilizer treatments both in 2018 and 2019 Table 8. In 2018, higher stem dry matter was observed (11.3%) in organic fertilizer (F1) treated plot which was followed by (10.5% and 10.2%) under F2P2 and F2P3, respectively. Whereas, lower stem dry matter (9.1%) receiving F2 source of fertilizers when the previous crop was P2 Fig. 4a. Similar trend was observed in stem dry matter due to fertilizer treatment under all the previous crops in 2019 Fig. 4b. Similar result was also found in the previous study of response of fertilizers on yield of Amaranthus types in coastal Karnataka [26]. The stem dry matter in different treatments varied possibly due to applied treatments effect.

Table 5. Plant height (cm) of stem amaranth as affected by previous crops and fertilizers management under vegetables – vegetables - Rice cropping system during kharif-1, 2018 and 2019

Fertilizer management	Previous crops			Mean
	Potato	Garlic	Cauliflower	
2018				
F1	65.0	83.5	65.8	71.4
F2	57.0	81.5	84.3	74.2
Mean	61.0 B	82.5 A	75.0 AB	
$LSD_{0.05}$ for Precrop	12.7*			
$LSD_{0.05}$ for Fertilizer	NS			
$LSD_{0.05}$ for Precrop x Fertilizer	NS			
CV%	16.4			
2019				
F1	61.8	68.0	72.5	67.3 B
F2	75.5	93.0	93.5	87.2 A
Mean	68.2	80.2	83.0	
$LSD_{0.05}$ for Precrop	NS			
$LSD_{0.05}$ for Fertilizer	11.2*			
$LSD_{0.05}$ for Precrop x Fertilizer	NS			
CV%	16.7			

*Mean value of the same category followed by different letters are significantly different from each other at P = 0.05 using LSD test. * Significant at 5% level of probability, NS= not significant, LSD least significant difference, CV = coefficient of variation, F_1= Organic fertilizer (N based organic compost) and F_2= Inorganic fertilizer (Estimated inorganic fertilizer dose based on the soil test value without cow dung)*

Table 6. Leaves per plant of stem amaranth as affected by previous crops and fertilizers management under vegetables – vegetables - Rice cropping system during kharif-1, 2018 and 2019

Fertilizer Management	Previous crops			Mean
	Potato	Garlic	Cauliflower	
2018				
F1	24.4	25.0	21.8	23.7 B
F2	48.0	25.8	31.0	34.9 A
Mean	36.2 A	25.3 B	26.4 B	
$LSD_{0.05}$ for Precrop	3.7*			
$LSD_{0.05}$ for Fertilizer	3.0*			
$LSD_{0.05}$ for Precrop x Fertilizer	5.2*			
CV%	11.7			
2019				
F1	22.5	23.0	20.0	21.7 B
F2	46.0	24.0	29.0	32.9 A
Mean	34.2 A	23.3 B	24.3 B	
$LSD_{0.05}$ for Precrop	3.7*			
$LSD_{0.05}$ for Fertilizer	2.9*			
$LSD_{0.05}$ for Precrop x Fertilizer	5.2*			
CV%	12.6			

*Mean value of the same category followed by different letters are significantly different from each other at P = 0.05 using LSD test. * Significant at 5% level of probability, NS= not significant, LSD least significant difference, CV = coefficient of variation, F_1= Organic fertilizer (N based organic compost) and F_2= Inorganic fertilizer (Estimated inorganic fertilizer dose based on the soil test value without cow dung)*

Table 7. Stem diameter(mm) of amaranth as affected by previous crops and fertilizers management under vegetables – vegetables - Rice cropping system during kharif-1, 2018 and 2019

Fertilizer Management	Previous crops			Mean
	Potato	Garlic	Cauliflower	
2018				
F1	15.5	15.8	15.3	15.5
F2	13.0	17.8	18.5	16.4
Mean	14.2	16.8	16.9	15.9
$LSD_{0.05}$ for Precrop			NS	
$LSD_{0.05}$ for Fertilizer	NS			
$LSD_{0.05}$ for Precrop x Fertilizer	NS			
CV%	16.4			
2019				
F1	17.5	14.8	16.3	17.2
F2	14.0	16.8	19.8	16.9
Mean	15.7	15.8	18.1	16.5
$LSD_{0.05}$ for Precrop	NS			
$LSD_{0.05}$ for Fertilizer	NS			
$LSD_{0.05}$ for Precrop x Fertilizer	NS			
CV%	16.4			

*Mean value of the same category followed by different letters are significantly different from each other at P = 0.05 using LSD test. * Significant at 5% level of probability, NS= not significant, LSD least significant difference, CV = coefficient of variation, F_1= Organic fertilizer (N based organic compost) and F_2= Inorganic fertilizer (Estimated inorganic fertilizer dose based on the soil test value without cow dung)*

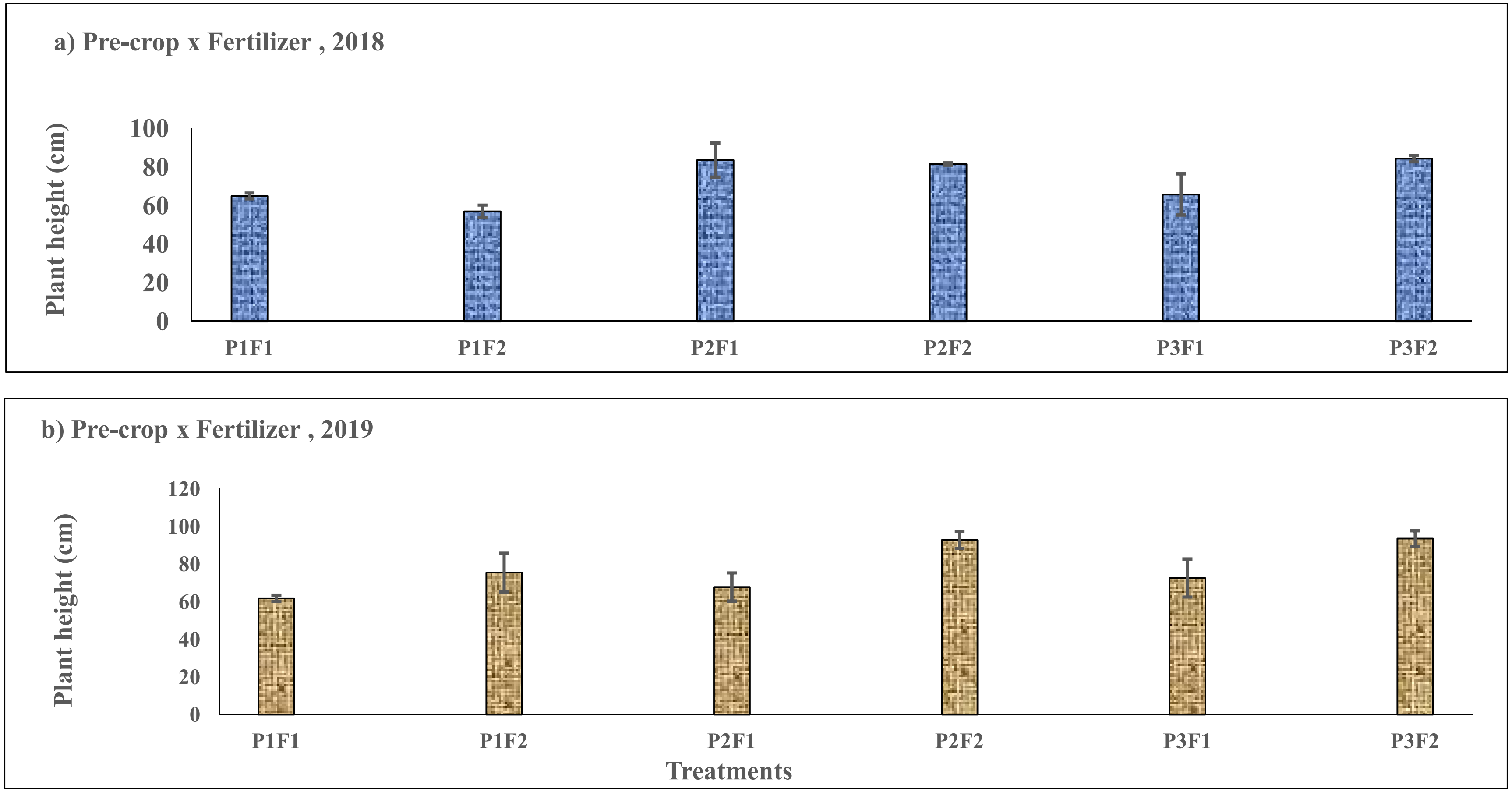

Fig. 1. Effect of the interaction of (a) Pre-crop x Fertilizer, 2018 and (b) Pre-crop x Fertilizer, 2019 on plant height of amaranth. Error bars represent standard error of the mean (n=4). Different lower case letters indicate significant differences between all treatments in each item (*P = 0.05*). P1: Potato; P2: Garlic; P3: Cauliflower; F1: Organic fertilizer; F2: Inorganic fertilizer

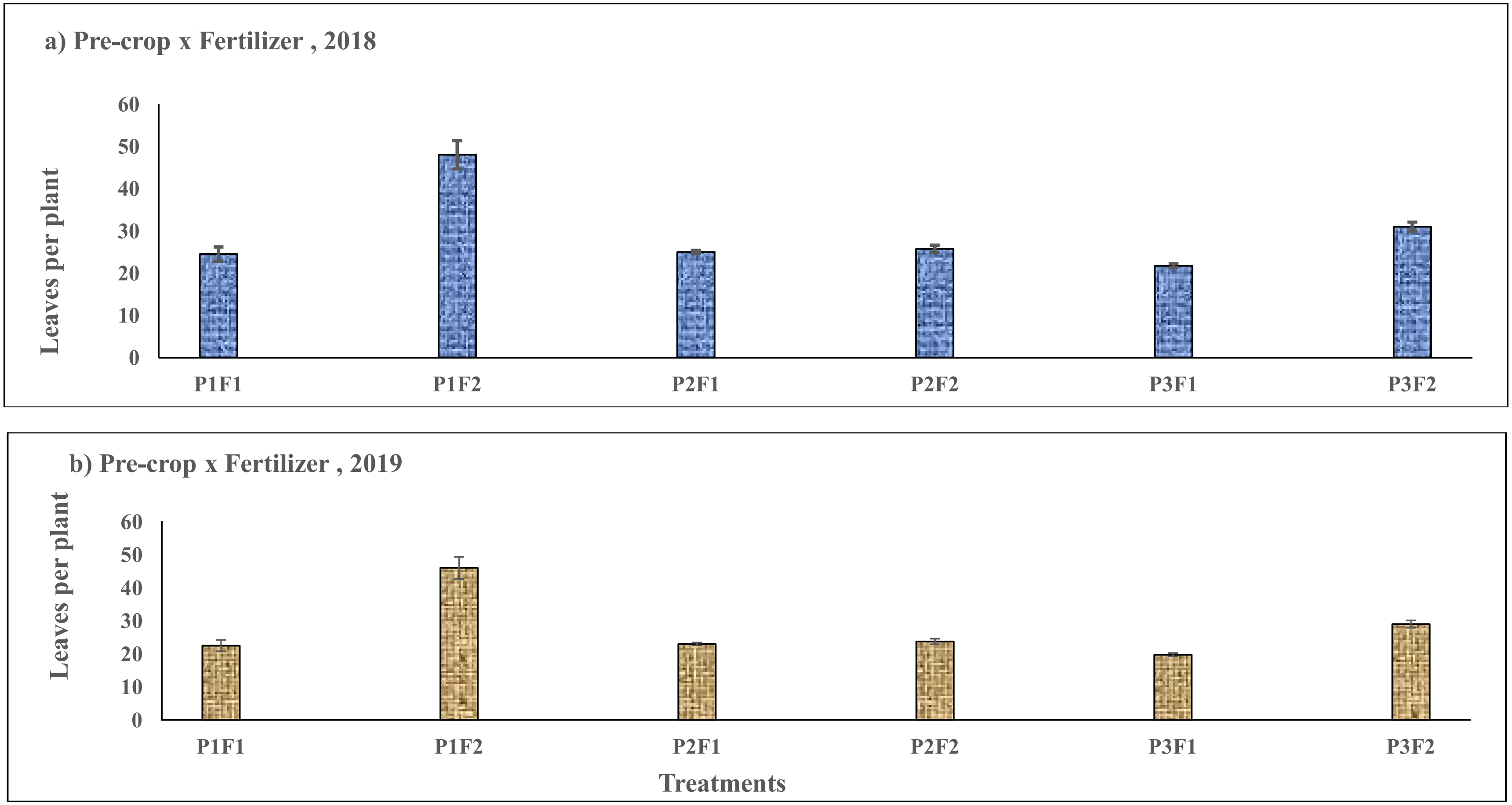

Fig. 2. Effect of the two-way interactions of (a) Pre-crop x Fertilizer, 2018 and (b) Pre-crop x Fertilizer, 2019 on leaves per plant of amaranth. Error bars represent standard error of the mean (n=4). Different lower case letters indicate significant differences between all treatments in each item (*P = 0.05*). P1: Potato; P2: Garlic; P3: Cauliflower; F1: Organic fertilizer; F2: Inorganic fertilizer

3.5 Stem Yield (t ha^{-1})

The interaction of previous crops and fertilizer application demonstrated insignificant effect on stem yield of amaranth both in 2018 and 2019. However, stem yield of amaranth was poor significant effect by the previous crops in 2018 and not significant effect in 2019 Table 9. In case of all previous crops, stem yield of amaranth was significantly distinct due to fertilizer application both in 2018 and 2019(Fig.5a-b). In 2018, higher stem yield was observed (38 t ha^{-1}) in (F2P3) treated plot which was followed by (36.1 t ha^{-1} and 35.5 t ha^{-1}) under F2P2 and F2P1, respectively. Whereas, lower stem yield (20.0 t ha^{-1}) receiving F1 source of fertilizers when the previous crop was P3 (Fig. 5a). Higher stem yield was observed (51.4 t ha^{-1}) in (F2P2) treated plot which was followed by (44 t ha^{-1}) under F2P3and F2P1, respectively. Whereas, lower stem yield (22.0 t ha^{-1}) receiving F1 source of fertilizers when the previous crop was P3 in 2019 (Fig. 4b). Result showed that, the application F1 fertilizer produced higher (>22 t ha^{-1}) stem yield of amaranth in 2019 than (>20 t ha^{-1}) stem yield in 2018 by all the pre-crops (Fig. 5a-b) due to all the F1 treated plots implying sufficient nitrogen release, coupled with nitrogen carryover from the previous crops, with resultant enhanced uptake and consequently higher crop yields. This is in agreement with the findings of [20-21] who reported that use of manures could help build soil fertility and increase nitrogen supply for the succeeding crops. Proportionate distribution of rainfall and better availability of sunshine hours at growth and maturity stages of amaranth with fertilizers during the cropping season in general and more availability of nutrients under soil test based inorganic fertilizer management treatment achieved higher yield performance in 2019 than in 2018. Similar result was also found by [27-28] in their research with fertilizers and manures where NPK (Recommended dose) fertilizers gave the highest yield for Indian spinach. The cause of this type of results may be because of huge and available nitrogen in recommended dose of fertilizers which facilitated to maintain leafy vegetative growth of Indian spinach. The stem yield in different treatments varied possibly due to applied treatments effect.

Table 8. Stem dry matter (%) of amaranth as affected by previous crop and fertilizers management under vegetables – vegetables - Rice cropping system during kharif-1, 2018 and 2019

Fertilizer Management	Previous crops			Mean
	Potato	Garlic	Cauliflower	
2018				
F1	11.3	10.5	10.2	10.7
F2	10.0	9.1	9.6	9.6
Mean	10.6	9.8	9.9	
$LSD_{0.05}$ for Precrop	2.45 NS			
$LSD_{0.05}$ for Fertilizer	2.0 NS			
$LSD_{0.05}$ for Precrop x Fertilizer	4.47 NS			
CV%	23.0			
2019				
F1	11.8	11.0	10.4	11.1
F2	10.0	9.1	10.1	9.7
Mean	11.0	10.1	10.2	
$LSD_{0.05}$ for Precrop	2.19 NS			
$LSD_{0.05}$ for Fertilizer	1.78 NS			
$LSD_{0.05}$ for Precrop x Fertilizer	3.10 NS			
CV%	19.8			

*Mean value of the same category followed by different letters are significantly different from each other at P = 0.05 using LSD test. * Significant at 5% level of probability, NS= not significant, LSD least significant difference, CV = coefficient of variation, F_1= Organic fertilizer (N based organic compost) and F_2= Inorganic fertilizer (Estimated inorganic fertilizer dose based on the soil test value without cow dung)*

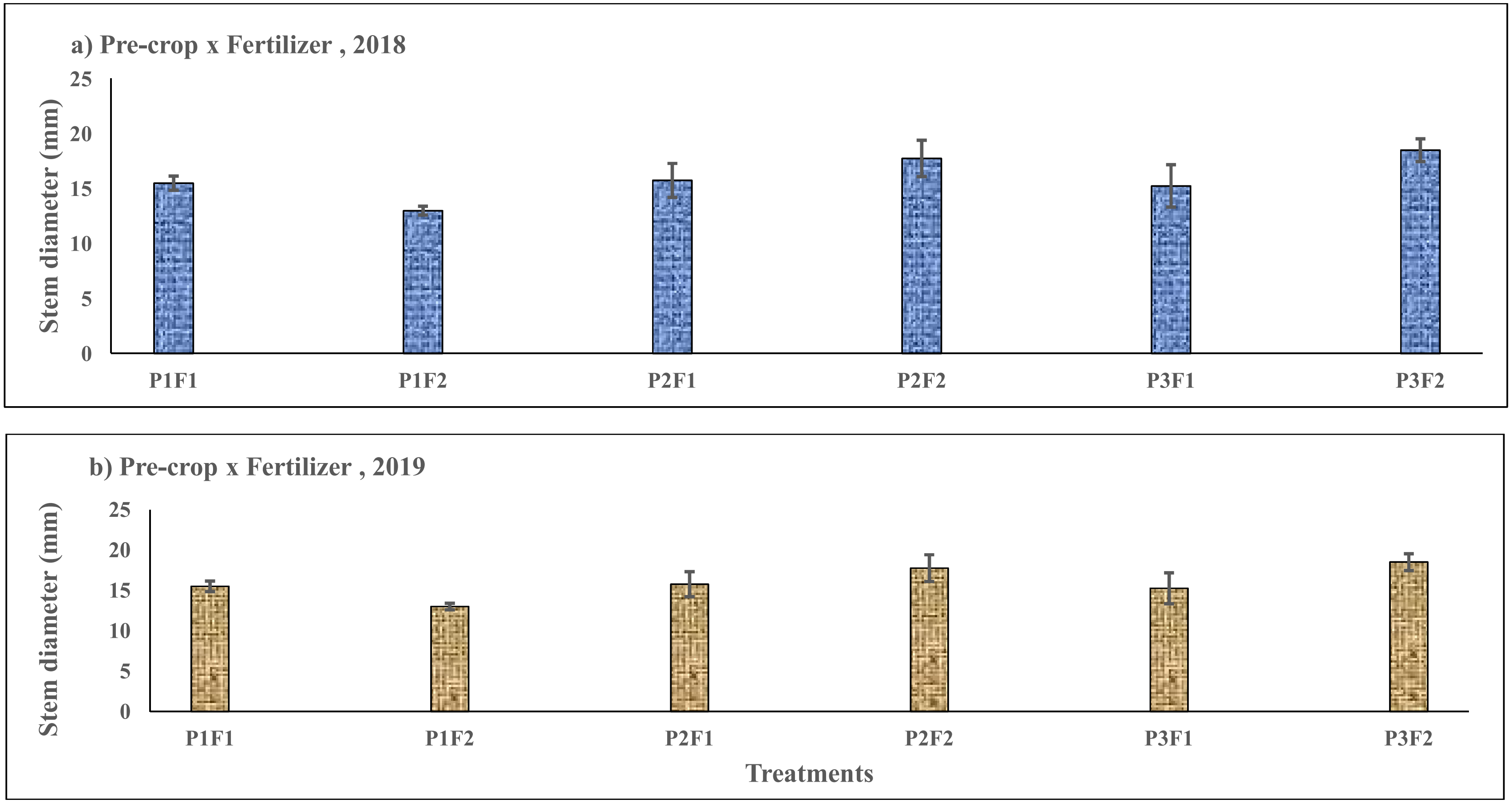

Fig. 3. Effect of the interaction of (a) Pre-crop x Fertilizer, 2018 and (b) Pre-crop x Fertilizer, 2019 on stem diameter of amaranth. Error bars represent standard error of the mean (n=4). Same lower case letters indicate no significant differences between all treatments in each item (*P = 0.05*). P1: Potato; P2: Garlic; P3: Cauliflower; F1: Organic fertilizer; F2: Inorganic fertilizer

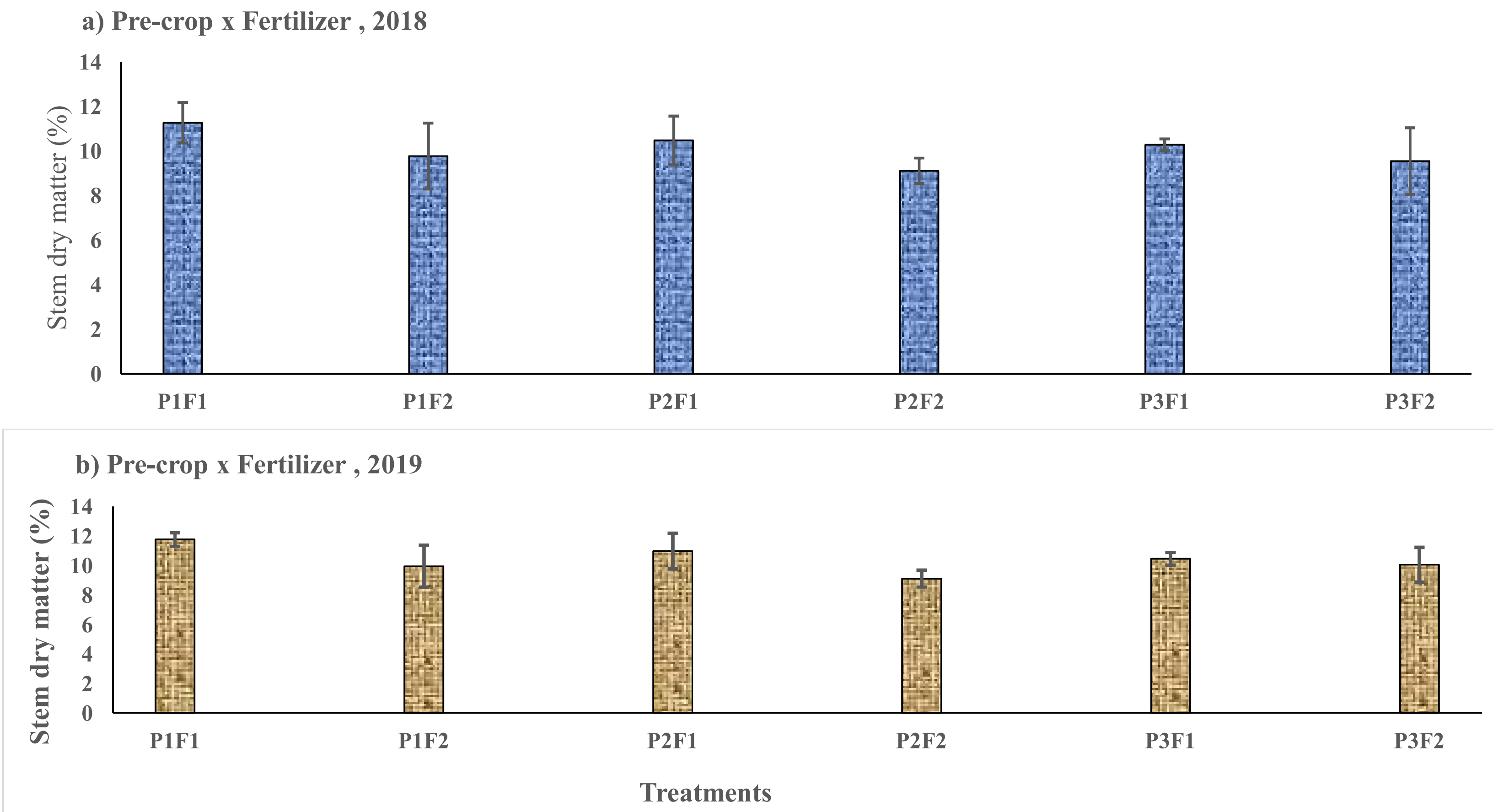

Fig. 4. Effect of the interaction of (a) Pre-crop x Fertilizer, 2018 and (b) Pre-crop x Fertilizer, 2019 on stem dry matter of amaranth. Error bars represent standard error of the mean (n=4). Same lower case letters indicate no significant differences between all treatments in each item (*P = 0.05*). P1: Potato; P2: Garlic; P3: Cauliflower; F1: Organic fertilizer; F2: Inorganic fertilizer

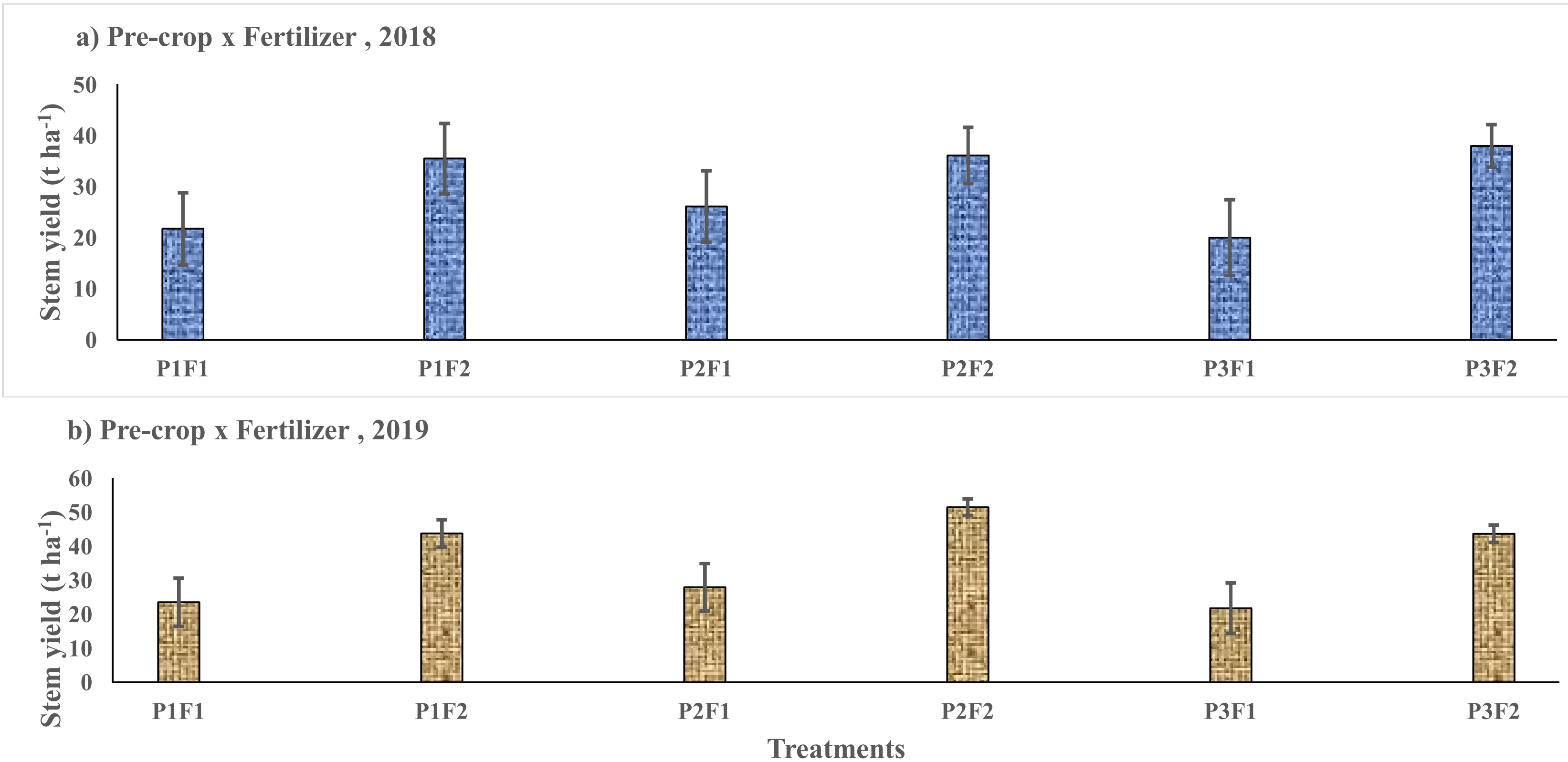

Fig. 5. Effect of the interaction of (a) Pre-crop x Fertilizer, 2018 and (b) Pre-crop x Fertilizer, 2019 on stem yield of amaranth. Error bars represent standard error of the mean (n=4). Different lower case letters indicate significant differences between all treatments in each item (*P = 0.05*). P1: Potato; P2: Garlic; P3: Cauliflower; F1: Organic fertilizer; F2: Inorganic fertilizer

Table 9. Stem yield (t ha^{-1}) of amaranth as affected by previous crops and fertilizers management under vegetables – vegetables - Rice cropping system during kharif-1, 2018 and 2019

Fertilizer Management	Previous crops			Mean
	Potato	Garlic	Cauliflower	
2018				
F1	21.8	26.1	20.0	22.6 B
F2	35.5	36.1	38.0	36.5 A
Mean	28.6	31.1	29.0	
$LSD_{0.05}$ for Precrop	3.7*			
$LSD_{0.05}$ for Fertilizer	3.0*			
$LSD_{0.05}$ for Precrop x Fertilizer	5.2*			
CV%	26.0			
2019				
F1	24.0	28.0	22.0	24.4 B
F2	44.0	51.4	44.0	46.2 A
Mean	33.6	39.6	32.7	
$LSD_{0.05}$ for Precrop	3.7*			
$LSD_{0.05}$ for Fertilizer	2.9*			
$LSD_{0.05}$ for Precrop x Fertilizer	5.2*			
CV%	24.6			

*Mean value of the same category followed by different letters are significantly different from each other at P = 0.05 using LSD test. * Significant at 5% level of probability, NS= not significant, LSD least significant difference, CV = coefficient of variation, F_1= Organic fertilizer (N based organic compost) and F_2= Inorganic fertilizer (Estimated inorganic fertilizer dose based on the soil test value without cow dung)*

4. CONCLUSION

From the above study it could be highlighted that previous crops had a positive impact on the yield parameters of stem amaranth like plant height in 2018 and leaf numbers of plant both in 2018 and 2019 Interaction effect of previous crops and fertilizers management exerted significant variations only on leaves per plant of amaranth both in 2018 and 2019. Whereas fertilizers management showed significant variation for plant height in 2019 and for stem yield both in 2018 and 2019.Proportionate distribution of rainfall and better availability of sunshine hours at growth and maturity stages of amaranth with fertilizers during the cropping season in general and more availability of nutrients under soil test based inorganic fertilizer management treatment achieved higher yield performance in 2019 than in 2018. Moreover, stem yield of amaranth was higher due to N based organic compost treated plots in 2019 compared to stem yield in 2018 under all the previous crops. But comparative results among all the three previous crops studied in the present investigation suggested that yield and yield parameters of stem amaranth were performed better when the pre-crop was garlic under Garlic - Amaranth - T. Aman cropping system due to soil test based inorganic fertilizer management and N based organic compost could be moderate yielding after previous crops.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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