

Development of Integrated Fertilizer Management Strategies in Lentil for Higher Productivity in the South-Western Region of Bangladesh

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Abstract

Due to the lack of optimum fertilizer management in low organic matter content soil is one of the limiting factors to the lower yield and productivity of lentil in Bangladesh. To increase the yield and maintain the sustainability of lentil production in the highly intensive cropping areas of Bangladesh the development of integrated fertilizer management is urgent. An experiment was conducted at Regional Agricultural Research Station, Jashore, Bangladesh during the rabi season of 2018-2019 to develop an integrated fertilizer management strategies for lentil in low organic matter content soil. The experiment was laid out in a split plot design where different fertilizer management techniques were allocated in the main-plots and different varieties were allocated in the sub-plots. There were five fertilizer management (FM) techniques such as FM1- Vermicompost 1t ha⁻¹ + (inorganic P:K:S @ 23:6:10 kg ha⁻¹) + 2% DAP foliar spray, FM2- Vermicompost 1t ha⁻¹ + (inorganic P:K:S @ 24:6:10 kg ha⁻¹) + 1% DAP foliar spray, FM3- (inorganic N:P:K:S @ 20:40:20:10 kg ha⁻¹) and no DAP foliar spray, FM4- Vermicompost 1t ha⁻¹ + (inorganic P: K: S @ 25:6:10 kg ha⁻¹) and no DAP foliar spray, FM5- control and there were three varieties such as V1-BARI Masur-6, V2-BARI Masur-7 and V3-BARI Masur-8.

The highest plant height (cm), plant density at harvest, leaf chlorophyll index, grain yield and the lowest days to 50% flowering and Stemphylium blight disease score was observed from the treatment combination FM1V3 (vermicompost 1t ha⁻¹ + (inorganic P:K:S @ 23:6:10 kg ha⁻¹) + 2% DAP foliar spray with lentil variety BARI Masur-8). The next best treatment combinations were FM1V2 (vermicompost 1t ha⁻¹ + (inorganic P:K:S @ 23:6:10 kg ha⁻¹) + 2% DAP foliar spray with lentil variety BARI Masur-7) and FM1V1 (vermicompost 1t ha⁻¹ + (inorganic P:K:S @ 23:6:10 kg ha⁻¹) + 2% DAP foliar spray with lentil variety BARI Masur-6), respectively. Integrated fertilizer management technique such as vermicompost 1t ha⁻¹ + inorganic P:K:S @ 23:6:10 kg ha⁻¹ + 2% DAP foliar spray with variety BARI Masur-8 may be recommended to farmers for sustainable lentil production.

Keyword: vermicompost, organic fertilizer, foliar spray, lentil

1. Introduction

People consume pulses as an important source of protein throughout the world. All over the world pulses are known as the poor man's meat (Hussain, 2016). Bangladesh produces several pulses such as lentil (*Lens culinaris*), grasspea (*Lathyrussativus*), blackgram (*Vignamungo*), mungbean (*Vignaradiata*), chickpea (*Cicerarietinum*), pea (*PeasumSATIVUM*), pigeon pea (*Cajanascajan*), cowpea (*Vignaunguiculata*) (Hussain, 2016). Lentil is one of the most ancient legume pulse and seems that it has been domesticated in the crescent about 8000 years ago (Zohary and Hopf, 2000). Among the pulses grown in Bangladesh about 41% area is covered by lentil (BBS, 2019). Lentil in Bangladesh is mainly growing in *rabi* season and major growing areas are Pabna, Jashore, Kushtia, Faridpur, Rajshahi, Magura, Jhenaidah and Madaripur districts (Azad et al., 2019). In the year 2018/19, Bangladesh produced about 0.17 million tons of lentil from its 0.35 million acres land (BBS, 2019). To fulfill the domestic demand country imported about 0.43 million tons of lentil from the foreign countries (The financial express, 2020). Low yield potential of local cultivars and susceptibility to major diseases, poor fertilizer and irrigation management, and delayed sowing are the major production constraints for lentil production in Bangladesh (Sarkar, 2004). For this reason, time to time several agronomic approaches has been taken to increase the lentil's productivity. Among them agronomic soil management using plant residue, application of FYM or vermi products are well known approaches (Rudrappa et al., 2006). Soil organic matter maintaining is very important to gain the long-term

productivity of crops including lentil (Janmohammadi et al., 2014). Vermicompost an organic fertilizer can enhance the soil organic matter and in addition, it improves the soil structure, water holding capacity, bulk density and enhances the microbial activity in soil (Adolph et al., 2002).

Chemical fertilizers recommended for lentil are not always works effectively due to the soil situations. Sometimes soil are not in favor to absorb of plant nutrient or sometime quick supply of essential nutrients are not conducive to soil, therefore foliar application of nutrient is a solution to that problem in that stage (Salisbury and Ross, 1985). Foliar spray of fertilizer helps the nutrient to go through directly in the site of food synthesis thus less wastage and quick supplement of nutrient which hasten sudden growth of lentil and it reduce the requirement of large quantity of fertilizer (Das and Jana, 2015). Foliar application of urea at 50% flowering stage enhanced the yield found by (Palta et al. 2005) and (Zeidan, 2003). Leaf senescence begins earlier in lentil before completing maturity and it hamper in the process of source to sink deployment resulted in yield reduction where nitrogen spray can delay the leaf senescence that hasten the productivity (Das and Jana, 2015).

Chemical fertilizers are essential for lentil but combination of chemical fertilizer, organic fertilizer or manure, foliar spray of nitrogenous and phosphorus fertilizer provides higher productivity over individual source of nutrient (Math et al., 2018). So it is obvious that there is a scope to increase lentil productivity by applying judicious fertilizer management including inorganic fertilizer, organic fertilizer and foliar spray of fertilizer. But the research work related to combined application of organic, inorganic and foliar spray of fertilizer in lentil is limited. Therefore, this experiment was initiated to investigate and to develop appropriate integrated fertilizer management strategies in lentil for its higher productivity and sustainability.

2. Materials and Methods

The experiment was conducted at Regional Agricultural Research Station (23°18' latitude and 89°18' longitude with the altitude of 19 m), Bangladesh Agricultural Research Institute, Jashore, Bangladesh during the rabi 2018-2019 season. The trial site falls under the Agro-Ecological Zone number eleven (AEZ-11) called the High Ganges River Floodplain (FRG, 2012). The climate at the experimental site is subtropical monsoon nature with high rainfall during May to October and scanty rainfall during November to April. Annual average rainfall is ~1600 mm. About 90% of the total rainfall occurs from May to October and the distribution of the rainfall is uneven and unpredictable. Monthly average temperature ranges from 20 °C in January to 35°C in April. The soil of the experimental field is sandy loam in texture and slightly alkaline in reaction (pH 7.5) having organic carbon of 1.6%. The experiment was conducted in split plot design in where different fertilizer management options were placed in main plots and different varieties were placed in subplots.

Table 1. The treatments details are explained

Mainplot treatment:Fertilizer management (FM) options	Treatment details
FM1- Vermicompost 1t ha ⁻¹ + inorganic P:K:S @ 23:6:10 kg ha ⁻¹ + 2% DAP foliar spray	Total vermicompost and other inorganic fertilizers were mixed with soil during the final land preparation and foliar spray of DAP was applied at 50% flowering stage.
FM2- Vermicompost 1t ha ⁻¹ + inorganic P:K:S @ 24:6:10 kg ha ⁻¹ + 1% DAP foliar spray	Total vermicompost and other inorganic fertilizers were mixed with soil during the final land preparation and foliar spray of DAP was applied at 50% flowering stage.
FM3- Inorganic N:P:K:S @ 20:40:20:10 kg ha ⁻¹ and no DAP foliar spray	Total inorganic fertilizers were mixed with soil during the final land preparation.
FM4- Vermicompost 1t ha ⁻¹ + inorganic P:K: S @ 25:6:10 kg ha ⁻¹ and no DAP foliar spray	Total vermicompost and other inorganic fertilizers were mixed with soil during the final land preparation.
FM5- Control	No fertilizers were used.
Sub-plot treatment: Varieties (V)	Features
V1: BARI Masur-6	Average plant height 35-40 cm, life cycle 110-115 days, yield 1800-2000kg ha ⁻¹ , resistance to rust and Stemphyllium blight disease.
V2: BARI Masur-7	Average plant height 32-38 cm, yield 1800-2100 kg ha ⁻¹ , suitable for growing all over the country.

V3: BARI Masur-8

Fe and Zn enriched, life cycle 110-115 days, yield 2100-2200 kg ha⁻¹, resistance to rust and Stemphyllium blight disease.

The unit plot size was 12.8 m² (3.28 m × 4 m) in where row to row distance was 40 cm and plant to plant distance was 5 cm. The land was ploughed three times using a cultivator drawn by a four wheels tractor. Seeds of the selected cultivars were sown on November 8, 2018 at the rate of 30 kg ha⁻¹. The seeds were treated using a fungicide namely provax @ 2.5g/kg seed. Weeds were managed by two times hand weeding at 30 DAS and 65 DAS. Fertilizers were applied as per the treatments. Irrigation was avoided. Crop was harvested on 22th February 2019. The harvested crop was sun dried for two days and threshed manually as plot wise. The data on days to flowering, days to mature, plants height (cm) at harvest, plant density, pods plant⁻¹, nodules plant⁻¹ at 50% flowering, chlorophyll index at 50% flowering, yield (kg ha⁻¹), and stemphyllium blight disease score (0-5) were recorded. The analysis of variances for the measuring parameters was performed using a statistical software statistix-10 and means were compared using Tukey's HSD at alpha = 0.05.

3. Results and Discussion

Days to 50% flowering: Different fertilizer management options, varieties and their interaction significantly affect the days to 50% flowering of lentil. The highest (61) and lowest (57) days to flowering was observed in interaction FM5V1 (control with BARI Masur-6) and FM1V3 (vermicompost 1t ha⁻¹ + inorganic P:K:S @ 23:6:10 kg ha⁻¹ + 2% DAP foliar spray with BARI Masur-8), respectively. It may be due to quick availability of nutrient as organic source of fertilizer and direct foliar spray of nutrient was applied in FM1V3 interaction treatment. Similar result was also found by (Janmohammadi et al., 2014). He observed organic source of fertilizer and foliar application of growth regulators improves both root and total above ground plant growth.

Days to maturity: In case of fertilizer management options and varieties, days to maturity was significant but their interaction was not significant. Fertilizer management options FM5 and FM1, respectively required the highest and lowest days to maturity. Considering by the varieties, the highest days required to maturity for variety V1 and V2 and the lowest days for variety V3.

Plant height: Plant height of lentil differed significantly due to different fertilizer management options, different varieties and their interaction. The highest plant height (42 cm) was observed due to the interaction effect of FM1V3 (vermicompost 1t ha⁻¹ + inorganic P:K:S @ 23:6:10 kg ha⁻¹ + 2% DAP foliar spray with BARI Masur-8) and the lowest plant height (31 cm) was found due to the interaction effect of FM5V3 (Control with BARI Masur-6). This result is at par with the finding of (Hossain et al., 2018). They showed that foliar application of DAP increases the plant height of lentil. Enlargement of plant height in lentil as influenced by additional nitrogen adjustment was also earlier reported by (Janloo et al., 2009) and (Niri et al., 2010).

Plant density at harvest: Plant density at harvest was significantly varied due to the different fertilizer management options, varieties and their interaction. The highest (201) and lowest (69) plants m⁻² was found from the interaction effect of FM1V3 (vermicompost 1t ha⁻¹ + inorganic P:K:S @ 23:6:10 kg ha⁻¹ + 2% DAP foliar spray with BARI Masur-8) and FM5V1 (control with BARI Masur-6), respectively.

Pods plant⁻¹: Fertilizer management options and varieties have significant effect on pods plant⁻¹ but there was no significant interaction effect. (Fatema et al., 2018) states that pods plant⁻¹ were maximum incase of 50:70:30-N:P:K+ 4t ha⁻¹ FYM application which is more or less similar to the present study.

Nodules plant⁻¹: Nodules plant⁻¹ differed significantly due to fertilizer management options and varieties but did not differ significantly due to their interaction effect. Interaction between different FYM quantity and different growth regulator were also found non-significant by (Janmohammadi et al., 2014) in increasing of nodules plant⁻¹. (Hossain et al., 2018) revealed that foliar application of TSP in lentil increases the no. of nodules plant⁻¹ which is similar to present findings.

Chlorophyll index: Chlorophyll index of lentil leaf was statistically significant in case of fertilizer treatments, varieties and for their interaction. The highest (23) chlorophyll index was observed in FM1V3 (vermicompost 1t ha⁻¹ + inorganic P:K:S @ 23:6:10 kg ha⁻¹ + 2% DAP foliar spray with BARI Masur-8) and the lowest (4) was found from the FM3V3 (inorganic N:P:K:S@ 20:40:20:10 kg ha⁻¹ and no DAP foliar spray with BARI Masur-8) and FM5V3 (control with BARI Masur-8) interaction. Phosphorus increases the N-fixing capacity of lentil as well as other legumes and in addition it also increases the chlorophyll content stated by (Singh et al., 2003). Foliar application of DAP supplied the nutrient phosphorus in the present study and probably this may help to increase the chlorophyll index in treatment combination FM1V3. Similar result was also found by (Janmohammadi et al., 2014).

Lentil grain yield: Grain yield of lentil was affected significantly by the fertilizer management options, different varieties and their interaction. The highest grain yield (2535 kg ha⁻¹) was observed from the treatment combination FM1V3 (vermicompost 1t ha⁻¹ + inorganic P:K:S @ 23:6:10 kg ha⁻¹ + 2% DAP foliar spray with BARI Masur-8) and the lowest grain yield (1118 kg ha⁻¹) was found from the treatment combination FM5V1 (control with BARI Masur-6) interaction effect. The higher grain yield in FM1V3 treatment may be for the positive effect of organic, inorganic and foliar sprayed fertilizer on growth and development of lentil. Similar results also reported by (Das and Jana, 2015). They concluded that significantly higher seed yield was found by 2% urea spray at pre flowering stage. (Math et al., 2018) revealed that vermicompost 2t ha⁻¹ + 37.5:75 N: P₂O₅ kg ha⁻¹ with 2% DAP spray gives the highest grain yield which is similar to this present research work. These findings are also in agreement with the findings of (Mandal and Majumdar 2001), (Gan et al., 2005), (Rabbi et al., 2011) and (Sharma, 1999).

Stemphylium blight (SB) disease score: The SB disease score differed significantly for fertilizer management options, varieties and their interaction. The highest (2.3) disease score was observed from the interaction effect of FM5V1 (control with BARI Masur-6) and the lowest score (0.0) was observed from the interaction effect of FM1V2 (vermicompost 1t ha⁻¹ + inorganic P:K:S-23:6:10 @ kg ha⁻¹ + 2% DAP foliar spray with BARI Masur-7). The fertilizer management options which contain organic matter and foliar spray had lower SB score than the control and it may be due to organic fertilizer make the nutrient available for the plants thus the plants become more vigorous and less susceptible to disease.

Table 2. Phenology, yield contributing characters and yield of lentil as affected by fertilizer management options

Fertilizer management options	Days to 50% flowering	Days to maturity	Plant height (cm)	Plants m ⁻² (no.)	Pods plant ⁻¹ (No.)	Nodules plant ⁻¹ (No.)	Chlorophyll index	Yield (kg ha ⁻¹)	*SB disease (0-5 scale)
FM1	58c	106b	39a	192a	108a	76a	20a	2338.7a	0.1b
FM2	59b	107b	37b	185b	99b	69b	14b	2103.4b	0.3b
FM3	59b	107b	34c	138c	82c	62c	12b	1863.2c	0.2b
FM4	59b	109a	33d	108d	73d	59c	12b	1591.6d	0.3b
FM5	60a	109a	32e	89e	64e	49d	8c	1288.2e	1.3a
SE	0.3	0.41	0.26	1.52	2.07	1.86	0.83	41.97	0.23
Lsd (.05)	0.69	0.97	0.61	3.51	4.79	4.29	1.93	85.9	0.54

Table 3. Phenology, yield contributing characters and yield of lentil as affected by varieties

Varieties	Days to 50% flowering	Days to maturity	Plant height (cm)	Plants m ⁻² (no.)	Pods plant ⁻¹ (no.)	Nodules plant ⁻¹ (no.)	Chlorophyll index	Yield (kg ha ⁻¹)	*SB disease (0-5 scale)
V1	59a	108a	34c	135c	81c	59c	14a	1749.2a	0.66a
V2	59a	108a	35b	143b	84b	63b	13ab	1858.3b	0.4ab
V3	58b	107b	37a	150a	90a	66a	12b	1903.5a	0.3b
SE	0.17	0.3	0.29	1.02	1.27	1.50	0.83	32.5	0.15
Lsd (.05)	0.35	0.62	0.61	2.15	2.65	3.14	1.74	66.6	0.32

Table 4. Phenology, yield contributing characters and yield of lentil as affected by the interaction of fertilizer management options and varieties

Interaction	Days to 50% flowering	Days to maturity	Plant height (cm)	Plants m ⁻² (no.)	Pods plant ⁻¹ (no.)	Nodules plant ⁻¹ (no.)	Chlorophyll index	Yield (kg ha ⁻¹)	*SB disease (0-5 scale)
FM1V1	59b	106	37c	183c	100	69	17bcd	2221b	0.3c
FM1V2	58bc	107	39b	192b	106	75	20ab	2260b	0.0c
FM1V3	57bc	105	42a	201a	118	83	23a	2535a	0.0c
FM2V1	59b	108	36cd	181c	96	65	10ef	2031d	0.0c
FM2V2	60a	107	36c	182c	96	68	10ef	2134bc	0.3c
FM2V3	58bc	106	39b	194b	104	73	15cd	2144bc	0.6bc
FM3V1	59b	108	33fg	135e	79	57	19bc	1835e	0.6bc
FM3V2	59b	107	35de	138de	83	63	18bc	1907de	0.0c
FM3V3	59b	106	36c	142d	85	65	4g	1847.7e	0.0c
FM4V1	59b	109	33fg	105gh	70	59	16bcd	1541fg	0.0c
FM4V2	59b	109	33fg	107fg	74	58	7fg	1571.7f	0.3c
FM4V3	59b	109	34ef	112f	76	59	13de	1662f	0.6bc
FM5V1	61a	110	31h	69j	62	45	10ef	1118i	2.3a
FM5V2	59b	109	32gh	98i	63	51	11ef	1418.3gh	1.3b
FM5V3	59b	109	32gh	101hi	66	52	4g	1328.3h	0.3c
SE	0.43	0.67	3.12	2.42	3.12	3.32	1.33	71.36	0.37
Lsd (.05)	0.95	NS	6.81	5.26	NS	NS	3.71	151.3	0.81

4. Conclusion

The research revealed that yield and yield attributing characters of lentil were influenced by different fertilizer management options, varieties and their interaction effect. On the basis of this research findings it seems that vermicompost 1t ha⁻¹+ inorganic P:K:S @ 23:6:10 kg ha⁻¹ + 2% DAP foliar spray with variety BARI Masur-8 is the best combination for maximizing the productivity of lentil. In general, it could be concluded that soil amendment with vermicompost, adequate inorganic fertilizer, foliar spray of nitrogenous and phosphorus fertilizer at pod initiation stage and with combined cultivation of high yielding variety such as BARI Masur-8 maximized the productivity of lentil.

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