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Effect of chemical fertilizers, farm yard manure and biofertilizers on quality of maize (*Zea mays* L.) under rainfed conditions of North Kashmir

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Abstract
Field experiment was conducted with maize variety Shalimar Maize Composite-4 (C-4) as a test crop during two consecutive *kharif* seasons of 2019 and 2020 in a silty clay loam soil at agricultural farm of Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura using split plot design with 18 treatment combinations and 3 replications. For the experiment, three levels of recommended chemical fertilizers (50, 75 and 100 per cent of N P K Zn), three levels of farm yard manure (10, 15 and 20 t ha^{-1}) and two levels of biofertilizers (Control and Azotobacter + Phosphate solubilising bacteria + Potassium solubilising bacteria) were used. The results indicated that with the increase in the recommended dose of chemical fertilizer from 50 per cent to 100 per cent the quality of grain increased. With the increase in the dose of farm yard manure from 10 t ha^{-1} to 20 t ha^{-1} the grain quality of maize also increased. Use of biofertilizers (Azotobacter + Phosphate solubilising bacteria + Potassium solubilising bacteria) significantly increased the grain quality of maize.

Keywords: Biofertilizers, chemical fertilizers, farm yard manure, maize, quality

Introduction
The second major cereal crop in the world with regards to land use is maize (*Zea mays* L.) which is regarded as the "Queen of Cereals" (Baradhan and Kumar, 2018) [1]. Maize is called as "Miracle crop" because of its higher productive potential compared to any other cereal crop (Paramasivan *et al*., 2013) [13]. It is being used for multi-purpose as a food source for mankind, feed for animals, fodder and as an excellent form of bio-fuel in the past as well as the present (Kaul *et al*., 2019) [8]. Maize is India's third most widely produced cereal crop, after paddy and wheat. Maize is a 'C4' and 'day neutral plant' it yields more in a shorter period of time that can be cultivated in any season (Ferrante and Mariani, 2018) [4]. Maize is one of the most adaptable crop allowing it to thrive in a variety of agro-climatic situations (Kumar *et al*., 2020) [9]. 85 per cent of the maize cultivated area in India is rainfed (Lone *et al*., 2017) [10]. Maize is being exhausting crop and it depletes a large part of soil nutrients unless the soil is provided with external supply of nutrients. Over reliance on use of chemical fertilizers has been associated with decline in soil physical and chemical properties and crop yields over time (Paul *et al*., 2009) [15]. Fertilizer management have significant influence on the chemical and nutritional composition of plants. This is possible only when chemical based inputs supplemented with biologically derived inputs, bio-resources and biofertilizers to supply nutrients (Panchal *et al*., 2018) [12]. Integrated use of organic and inorganic fertilizers not only increase mutual efficiency but also helps in the substitution of costly chemical fertilizers (Dilshad *et al*., 2010) [2].

Materials and Methods
The method for estimating the carbohydrate content in maize seed was by phenol sulphuric acid method as stated by Smith (2011) [16]. The absorbance was taken at 490 nm and linear regression equation obtained from standard curve was used to estimate carbohydrate in maize seed.

Linear regression equation X = (Y-0.2981)/0.0237

There are two steps to the colorimetric technique for lysine quantification in maize seed. The amino group in the α (alfa) of the lysine chain is protected in the first stage by a reaction with copper, which also blocked the amino group of low molecular weight peptides in the hydrolysate. The reaction of the 2-chloro-3, 5-dinitropyridine with the amino group in ξ (Xi) of the protected lysine chain produces a coloured ξ-dinitropyridil lysine, which is measured spectroscopically at 390 nm (Galicia *et al.*, 2008) [5].

The data recorded for different parameters were statistically evaluated according to the procedure outlined by Gomez and Gomez (1984) [6]. The critical difference was analysed by using SPSS software version 27.0 (SPSS, 2020). Preparation of tables and graphs were done in MS Excel spreadsheet.

Results and Discussion

1. Carbohydrate content in maize seed

Effect of chemical fertilizers, organic manures and biofertilizers on carbohydrate content in maize seed during both the years 2019 and 2020 and pooled data is presented in Table 1 (depicted in Figure 1 and 2). From the data it was observed that with the increase in the recommended chemical fertilizer dose from 50 per cent to 100 per cent, the carbohydrate content in maize seed increased from 70.23 to 73.55 per cent in the year 2019, from 69.23 to 72.55 per cent in the year 2020 and from 69.73 to 73.05 in pooled data. Our results are also supported by the findings of Ewais *et al.* (2015) [3] and Madhurya *et al.* (2021) [11] in maize.

With the increase in the dose of farm yard manure from 10 to 20 t ha^{-1} the carbohydrate content in maize seed increased from 68.00 to 75.72 per cent in the year 2019, from 67.00 to 74.72 per cent in the year 2020 and from 67.50 to 75.22 per cent in the pooled data. Similar results were also reported by Ewais *et al.* (2015) [3] and Madhurya *et al.* (2021) [11] in maize.

With the inoculation of biofertilizers (*Azotobacter*, PSB and KSB) a significant increase in the carbohydrate content in maize seed is observed over control (without biofertilizer inoculation) from 70.88 to 73.07 per cent in the year 2019, from 69.88 to 72.07 per cent in the year 2020 and from 70.38 to 72.57 per cent in the pooled data. Role of biofertilizers in improving carbohydrate content in maize seed is also reported by Panchal *et al.* (2018) [12] and Madhurya *et al.* (2021) [11].

Table 1: Effect of chemical fertilizers, organic manures and biofertilizers on carbohydrate content (per cent) in maize seed

Treatment	Carbohydrate content (per cent)		
	2019	2020	Pooled
Recommended Chemical Fertilizer (%)			
50 N P K Zn	70.23	69.23	69.73
75 N P K Zn	72.14	71.14	71.64
100 N P K Zn	73.55	72.55	73.05
CD ($p \leq 0.05$)	1.50	1.60	1.60
SEm ±	0.50	0.50	0.55
Farm Yard Manure (t ha^{-1})			
10	68.00	67.00	67.50
15	72.21	71.21	71.71
20	75.72	74.72	75.22
CD ($p \leq 0.05$)	2.76	2.00	2.30
SEm ±	0.90	0.65	0.80
Biofertilizers (2.5 kg ha^{-1} soil application)			
Control (Without Biofertilizer)	70.88	69.88	70.38
Biofertilizers (With *Azotobacter* + *PSB* + *KSB*)	73.07	72.07	72.57
CD ($p \leq 0.05$)	2.10	2.00	1.50
SEm ±	0.70	0.65	0.50

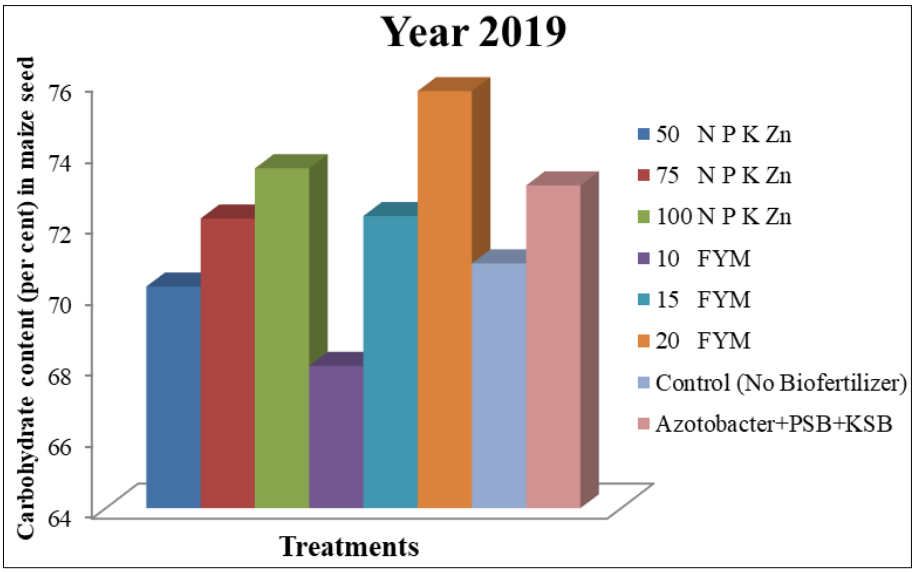

Fig 1: Carbohydrate content in maize seed during the year 2019

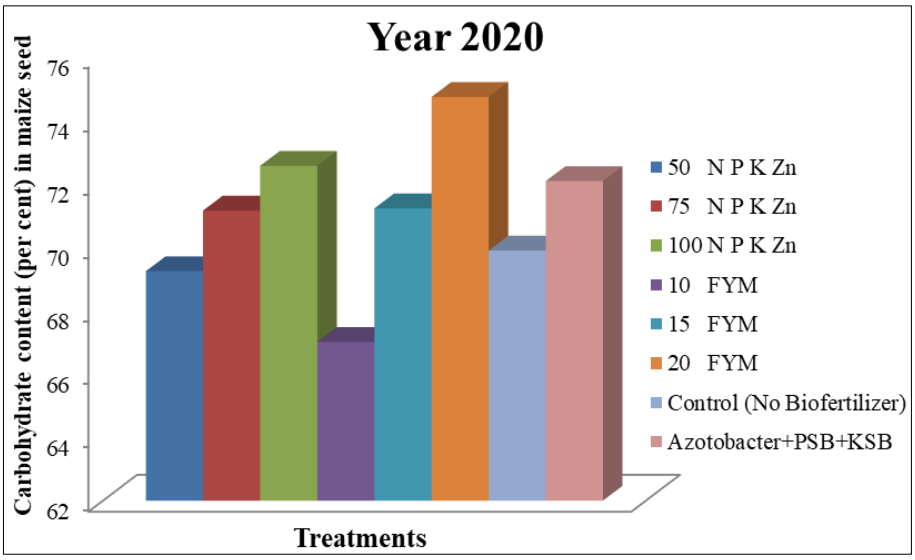

Fig 2: Carbohydrate content in maize seed during the year 2020

2. Lysine content in maize seed

Effect of chemical fertilizers, organic manures and biofertilizers on lysine content in maize seed during both the years 2019 and 2020 and pooled data is presented in Table 2 (depicted in Figure 3 and 4). From the data it was observed that with the increase in the recommended chemical fertilizer dose from 50 per cent to 100 per cent, the lysine content in maize seed increased from 1.98 to 2.69 per cent in the year 2019, from 2.03 to 2.72 per cent in the year 2020 and from 1.99 to 2.70 per cent in pooled data. The results are also similar with the findings of Paramesh *et al*. (2014) [14].

With the increase in the dose of farm yard manure from 10 to 20 t ha^{-1} the lysine content in maize seed increased from 2.00 to 2.72 per cent in the year 2019, from 2.05 to 2.78 per cent in the year 2020 and from 2.02 to 2.75 per cent in the pooled data. Our results are also similar with the findings of Paramesh *et al*. (2014) [14].

With the inoculation of biofertilizers (*Azotobacter*, PSB and KSB) there was a significant increase in the lysine content in maize seed over control (without biofertilizer inoculation) from 2.34 to 2.43 per cent in the year 2019, from 2.39 to 2.49 per cent in the year 2020 and from 2.36 to 2.46 per cent in the pooled data were observed. Our results are also similar with the findings of Paramesh *et al*. (2014) [14].

Table 2: Effect of chemical fertilizers, organic manures and biofertilizers on lysine content (per cent) in maize seed

Treatment	Lysine content (per cent)		
	2019	2020	Pooled
Recommended Chemical Fertilizer (%)			
50 N P K Zn	1.98	2.03	1.99
75 N P K Zn	2.10	2.20	2.15
100 N P K Zn	2.69	2.72	2.70
CD ($p \leq 0.05$)	0.30	0.15	0.20
SEm ±	0.10	0.05	0.17
Farm Yard Manure (t ha^{-1})			
10	2.00	2.05	2.02
15	2.33	2.42	2.37
20	2.72	2.78	2.75
CD ($p \leq 0.05$)	0.28	0.32	0.32
SEm ±	0.09	0.11	0.11
Biofertilizers (2.5 kg ha^{-1} soil application)			
Control (Without Biofertilizer)	2.34	2.39	2.36
Biofertilizers (With *Azotobacter* + *PSB* + *KSB*)	2.43	2.49	2.46
CD ($p \leq 0.05$)	0.06	0.07	0.08
SEm ±	0.02	0.02	0.03

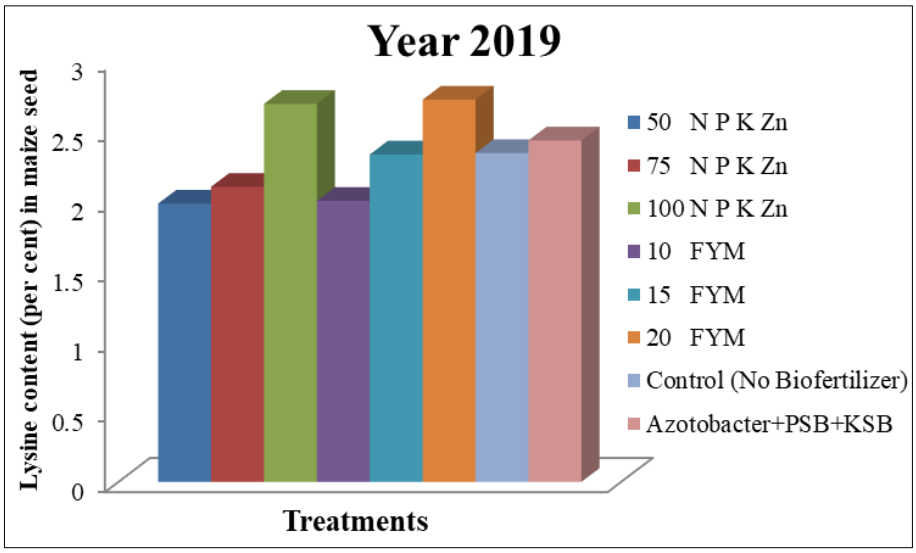

Fig 3: Lysine content in maize seed during the year 2019

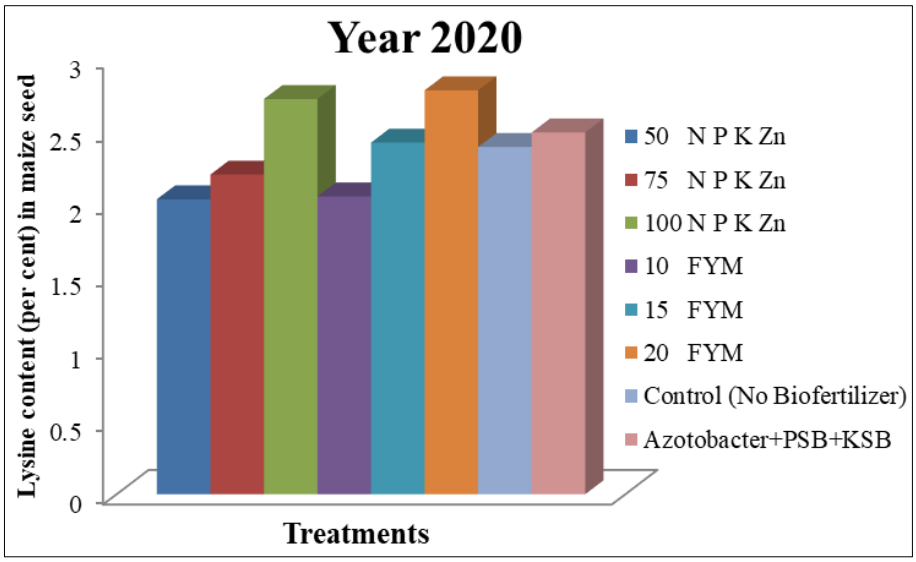

Fig 4: Lysine content in maize seed during the year 2020

Conclusion

Quality parameters like carbohydrate content and lysine content in the maize seed were improved with the increased use of recommended dose of chemical fertilizers from 50 to 100 per cent. With the increased dose of farm yard manure from 10 to 20 t ha^{-1} the quality parameters were also increased. Due to the inoculation of biofertilizers (*Azotobacter*, PSB and KSB) the quality parameters of maize were improved and performed well over control (no inoculation).

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