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EFFECTS OF HUMIC ACID, MICROBIOLOGICAL FERTILIZER AND PHOSPHATE ROCK ON YIELD AND YIELD COMPONENTS OF FIELD BEAN (*PHASEOLUS VULGARIS* L.)

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ABSTRACT

Experiments were conducted over the experimental fields of Erciyes University with Göynük 98 dry bean cultivar (*Phaseolus vulgaris* L.) in randomized blocks split-split plots experimental design with 4 replications during 2015 and 2016 growing seasons. Humic acid (HA) treatments (two applications, 2 kg da^{-1}) were placed in main plots, microbial fertilizer (MF) treatments (two applications, phosphate-solubilizing *Bacillus pumilus* C26) were placed in subplots and phosphate rock (PR) treatments (4 applications, 29.3% P_2O_5, 0, 7.5, 15 and 22.5 kg da^{-1}) were placed in sub-subplots. Plant and soil samples were taken from the experimental plots for the analyses of yield and yield components. HA, MF and PR treatments had different effects on investigated parameters of dry beans. As the average of the years, plant heights, the first pod heights, number of pods per plant, number of seeds per plant, number of seeds per pod, seed yield, harvest index values, biological yields, hundred-seed weights and seed protein ratios varied respectively between 42.95-53.65 cm, 10.16-13.90 cm, 13.85-24.85, 38.64-59.83, 2.36-3.16, 173.8-314.3 kg da^{-1}, 31.25-39.73%, 274.4-382.0 kg da^{-1}, 38.92-43.10 g and 22.93-24.94%. The greatest yield was obtained from the greatest phosphate rock dose applied together with humic acid and microbial fertilizer. All treatments significantly increased seed yields as compared to the control group (173.8 kg da^{-1}). It was concluded based on present findings that 22.5 kg da^{-1} (29.3% P_2O_5) phosphate rock together with humic acid and microbial fertilizer could be recommended for both organic and conventional dry bean farming.

KEYWORDS:
Bean, humic acid, microbial fertilizer, organic farming, phosphate rock, yield components

INTRODUCTION

Bean pods are consumed fresh and seeds are consumed dry. Bean seeds are quite rich in protein, thus commonly used in human nutrition. Plant vegetative parts are also used in feed industry (*Phaseolus vulgaris* L.). With all these attributes, bean is considered as a significant legume crop [1, 2]. Together with increasing world population, healthy and balanced nutrition have become a significant issue especially in developing countries. Average protein consumption per capita worldwide is 70.9 g [3, 4] and a quality and balanced nutrition can be mentioned when 60% of such a quantity was plant and 40% was animal originated [4]. Worldwide, 22% of plant-originated proteins and 7% of carbohydrates used in human nutrition is supplied from edible legumes; 38% of proteins and 5% of carbohydrates used in animal nutrition is supplied from again edible legumes [5, 6]. Among the edible legumes, dry bean is cultivated over 29.392.817 ha land area worldwide and annual production is 26.833.394 tons. With such a quantity of production, dry bean has the first place among edible legumes [7]. In Turkey, dry bean is cultivated over 897.221 da land area and annual production is 239.000 tons. With that production, dry bean has the third place among edible legumes of Turkey [8]. Organic dry bean production was practiced in Turkey in 2017 and 1.622,63 tons organic dry bean was produced annually [9]. As it was in conventional farming, macro and micronutrient needs limit the agricultural production also in organic farming. Among the macro nutrients, phosphorus is generally immobile, thus plant phosphorus uptake from the soil and mobility is quite limited [10]. In organic farming, phosphate rock can be used as a source of phosphorus. However, low solubility level of phosphate rock promoted the use of bacteria in agricultural practices. Bacteria have a significant place among microbial fertilizers. Bacteria play an important role in nitrogen fixation, plant hormone and vitamin synthesis, in prevention of ethylene

TABLE 1
Monthly average temperature (°C), precipitation and relative humidity (%) values for the years 2015 and 2016 and long-term averages

Months	Temperature (°C)			Total precipitation (mm)			Relative humidity (%)		
	2015	2016	Long-term	2015	2016	Long-term	2015	2016	Long-term
May	15.4	12.2	15.1	57.2	129.2	51.8	57.5	64.8	60.5
June	18.2	17.6	19.1	98.8	30.3	40.4	66.2	56.1	55.3
July	22.8	20.1	22.6	0.5	10.4	9.9	48.4	45.9	49.1
August	24.3	22.5	22.1	9.6	0	6.1	48.5	43.2	49.5

Source: Kayseri Provincial Directorate of Meteorology

TABLE 2
Daily maximum temperatures (°C) for July of the years 2015 and 2016

Years	Days																													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**
2015	28.0	28.0	28.0	28.7	29.3	30.7	29.3	24.2	26.0	31.0	31.7	27.4	27.2	30.0	30.5	29.9	28.5	29.1	30.7	31.6	32.4	31.8	33.0	37.3	33.9	34.4	33.8	34.0	35.6	37.0	35.4
2016	28.0	30.0	30.5	29.1	27.2	30.2	31.8	27.7	27.4	29.1	27.7	31.5	33.6	35.2	36.2	36.6	37.3	37.6	33.1	32.2	31.6	31.1	31.7	29.9	29.8	31.1	31.1	31.1	30.3	31.3	30.6

Source: Kayseri Provincial Directorate of Meteorology

synthesis, improvement of nutrient uptake and resistance to stress conditions, promotion of plant growth and development through increasing solubility and mineralization of organic phosphate [11, 12, 13]. Previous researchers reported that phosphate-solubilizing microorganisms transformed phosphate rock or insoluble phosphorus forms into soluble forms through acidization, chelating or exchange reactions [14, 15, 16]. In this way, greater and easier uptake is provided for phosphorus with limited availability in soils [16, 17, 18]. Of the organic fertilizers, humic and fulvic acids have colloidal characteristics; they can easily bound to sand, silt and clay-like soil fractions, thus improve aggregate formation and soil texture [19, 20, 21, 22, 23]. Humic and fulvic acids with their positive impacts on soil physical, chemical and biological characteristics significantly increase plant yield and quality [23].

In this study, effects of phosphorus-solubilizing bacteria and humic acid (a significant soil stabilizer) treatments on phosphorus availability were investigated through the experiments conducted to determine the effects of these treatments on dry bean yield and yield parameters. Potential use of present treatments in organic dry bean farming was also investigated.

MATERIALS AND METHODS

Experiments were conducted over the experimental fields of Erciyes University Agricultural Research and Implementation Center (38° 42' 54 N; 35° 32' 45 E and 1086 m above sea level) in Kayseri province during the vegetation periods of the years 2015 and 2016. Göynük 98 bean cultivar was used as the plant material of the experiments. Phosphate rock containing 29.30% P_2O_5 was supplied from Gübretaş Co. and humic acid (plant-originated and organic-certificated "Humanica") was supplied from Yeditepe University. Humanica contains 40% organic matter and 50% total humic and fulvic acid. Phosphate-solubilizing bacteria of *Bacillus pumilus* C26 was used as the microbial fertilizer. In the first year, experimental soils had 7.70% clay, 8.82% silt and 83.98% sand and available phosphorus level was 3.63 kg da^{-1}; in the second year, experimental soils had 13.94% clay, 12.48% silt and 73.58% sand and available phosphorus level was 5.36 kg da^{-1}.

As compared to long-term averages, monthly average temperatures throughout the vegetation periods varied ± 2 °C (Table 1). However, daily maximum temperatures in July (Table 2) negatively influenced initial flowering, pollination and pod-set of plants from the 12th of the June especially of the second year. With regard to precipitations per square meter, May of the second year had almost 2.5 times greater precipitation than the long-term average.

Experiments were conducted in randomized blocks split-split plots experimental design with 4 replications. Experiments were set on 12th of May of the first year and 9th of May of the second year. Humic acid treatments (two applications, 2 kg da^{-1}) were placed in main plots, microbial fertilizer treatments (two applications, phosphate-solubilizing *Bacillus pumilus* C26) were placed in subplots and phosphate rock treatments (4 applications, 29.3% P_2O_5, 0, 7.5, 15 and 22.5 kg da^{-1}) were placed in sub-subplots (2 × 2 × 4 × 4 = 64). Sowing was performed as to have 0.45 m row spacing and 0.10 m on-row plant spacing. There were 6 rows in each plot and row length was 3 m. Sprinkler irrigation was performed initially to prevent a duff layer and thus to have homogeneous emergence. Following weed control practices and earthing-up, drip irrigation was used to meet plant water needs. At the end of the experimental period, 10 plants were sampled from each plot taking side effects (one row from both sides and

0.5 m from top and bottom of the plots) into consideration. These samples were used to analyze yield and yield parameters (plant height, the first pod height, number of main branches per plant, number of pods per plant, number of seeds per plant, number of seeds per pod, seed yield, biological yield, hundred-seed weight and seed protein ratio) [24, 25]. Resultant data were subjected to variance analysis with Genstat software and Duncan's multiple range test was used to compare significant means [26].

RESULTS AND DISCUSSION

Variance analysis revealed that humic acid + microbial fertilizer + phosphate rock (HA + MF + PR) triple interactions had insignificant effects on number of main branches per plant and seed protein ratio in both years; insignificant effects on hundred-seed weight in the first year, but significant effects in the second year ($P \leq 0.05$); significant effects on number of seeds per plant in the first year ($P \leq 0.01$), but insignificant effects in the second year; significant effects on number of pods per plant in the first ($P \leq 0.05$) and the second year ($P \leq 0.01$). HA + MF + PR triple interactions had significant effects on the other yield parameters in both years ($P \leq 0.01$) (Table 3).

The greatest plant height was obtained from HA + PR3 treatments in the first (52.15 cm) and the second year (55.25 cm) of the experiments. The shortest plant height was obtained from the control groups without any treatments (37.93 cm in the first and 48.00 cm in the second year). Plant heights increased with increasing phosphate rock doses. As compared to control treatments, increasing phosphate rock doses increased plant heights of humic acid and microbial fertilizer treatments (Table 3). Complying with the present findings, increasing plant heights were reported with humic acid treatments Shaaban et al. [27] and increasing phosphorus doses [28, 29].

In plots only with increasing phosphate rock doses, the first pod height continuously increased with increasing phosphate rock doses and the greatest first pod height was obtained from PR3 treatments (12.36 cm in the first year and 13.50 cm in the second year). The lowest value was obtained from HA treatment (9.73 cm) in the first year and from HA + MF treatment (10.00 cm) in the second year. Similarly, in humic acid and HA + MF treatments, the first pod height increased with increasing phosphate rock doses (Table 3). Previous researchers reported increasing first pod heights with humic acid [30], humic acid and phosphorus [31], phosphorus and sulphur [32], phosphorus sources and phosphorus-solubilizing bacteria [33, 34] and phosphate rock treatments [35].

The greatest number of pods per plant was obtained from HA + MF + PR3 treatments (26.85 in the first year and 22.84 in the second year). As compared to control group without any treatments, 104.5% greater value was observed in the first year and 56.8% greater value was observed in the second year. In general, single microbial fertilizer and humic acid treatments significantly increased number of pods per plant (Table 3). Previous researchers also reported increasing number of pods per plant with potassium humate [36] and phosphorus [28, 29] treatments.

In the first year of the experiments, the lowest number of seeds per plant was obtained from PR3 (38.90 seeds) dose without humic acid and microbial fertilizer treatments, but the treatment was placed into the same statistical group with the control (44.18 seeds) treatment. On the other hand, as compared to control treatment, all the other treatments increased number of seeds per plant. The greatest values were obtained from HA + MF + PR2 (75.55 seeds) and HA + MF + PR3 (74.65 seeds) treatments and they were placed into the same statistical group. Parallel results were also observed in the second year. However, increasing temperatures from the Mid-July, coinciding with intensive flowering and pod set periods of the plants (Table 2) significantly reduced the number of pods per plant (Table 3). In any cases, humic acid and microbial fertilizer treatments significantly increased number of pods per plant. As compared to control treatment, significantly increasing number of pods per plant values were observed with increasing phosphate rock doses. Previous researchers also reported significant increases in number of pods per plant with humic acid [30], humic acid and phosphorus [31], phosphorus and phosphorus-solubilizing bacteria [33] and humic acid and rhizobium bacteria [37]. It was also reported in previous studies that use of phosphorus sources with plant growth-promoting bacteria [38], use of phosphates-solubilizing bacteria with chemical fertilizers [34] and use of phosphorus with bio-fertilizers [39] significantly improved plant yield parameters.

Number of seeds per pod values varied between 2.48-3.86 in the first year and between 1.92-2.46 in the second year (Table 3). Bean plants were negatively influenced by high temperatures especially at flowering and pollination periods [40]. As compared to the first year, higher temperatures of second year decreased number of seeds per pod. In general, as compared to control treatments, humic acid and microbial fertilizer treatments did not increase number of seeds per pod significantly.

The lowest seed yield was obtained from the control group in both years (214.8 kg da^{-1} in the first and 133.0 kg da^{-1} in the second year). As compared to control treatment, all treatments increased seed yields. Parallel results were observed in both years. In humic acid and microbial fertilizer treatments, seed yields increased with increasing phosphate rock doses. The greatest value was obtained from HA + MF + PR3 treatments in both years (395.9 kg da^{-1} in

TABLE 3
Mean values and variance analysis for yield and yield components of HA, MF and PR-treated dry beans

Year	Treatments			Plant Height (cm)	First Pod Height (cm)	Number of Pods per Plant	Number of Seeds per Plant	Number of Seeds per Pod	Seed Yield (kg/da)	Harvest Index (%)	Biological Yield (kg/da)	Hundred-Seed Weight (g)	Seed Protein Ratio (%)
2015	Humic Acid (-)	Microbial Fertilizer (-)	PR0	37,93 d	10,07 c	13,13 b	44,18 b	3,37	214,8 d	29,77 ab	297,3 d	39,841	20,54
			PR1	42,65 c	11,29 b	17,05 a	54,35 a	3,18	277,6 b	30,55 a	313,2 c	42,201	23,438
			PR2	46,38 b	11,63 ab	18,28 a	61,60 a	3,39	305,9 a	29,56 b	331,4 b	40,703	22,763
			PR3	49,53 a	12,36 a	12,65 b	38,90 b	3,07	263,8 c	24,51 c	361,4 a	40,56	23,955
		Microbial Fertilizer (+)	PR0	45,63 b	11,69 b	14,90 c	57,58 a	3,86 a	300,5 c	26,13 c	364,1 c	40,969	21,91
			PR1	49,10 a	12,61 a	22,90 a	66,38 a	2,90 b	335,3 a	27,41 b	481,7 a	41,754	23,423
			PR2	44,50 c	10,81 b	20,15 b	66,58 a	3,31 bc	315,2 b	31,81 a	428,3 b	41,383	24,275
			PR3	42,95 d	9,74 c	13,00 d	42,20 b	3,25 c	284,3 d	31,93 a	436,9 b	39,935	22,515
	Humic Acid (+)	Microbial Fertilizer (-)	PR0	38,35 d	9,73 c	13,18 d	50,63 bc	3,84 a	243,8 d	27,92 c	314,1 d	40,151	22,138
			PR1	41,98 c	10,32 bc	18,00 b	58,00 b	3,22 b	288,8 c	28,20 c	340,6 c	40,691	24,243
			PR2	47,53 b	10,87 ab	20,65 a	67,78 a	3,29 bc	320,3 a	31,20 a	409,9 a	41,006	22,625
			PR3	52,15 a	11,67 a	16,55 c	47,00 c	2,84 c	296,3 b	30,21 b	367,7 b	39,756	23,338
		Microbial Fertilizer (+)	PR0	38,05 c	10,52 c	19,78 c	59,58 b	3,01 ab	326,0 d	30,058	408,3 d	41,353	23,13
			PR1	44,30 b	12,41 b	25,33 a	62,70 b	2,48 c	344,0 c	30,403	433,0 c	42,457	23,888
			PR2	47,55 a	12,21 b	22,30 b	75,55 a	3,39 a	359,4 b	30,173	487,5 b	41,059	22,788
			PR3	43,35 b	13,31 a	26,85 a	74,65 a	2,78 bc	395,9 a	30,585	504,8 a	41,028	22,698
	General Means		Humic Acid (-)	44,831	11,274	16,506	53,969	3,289	287,2	28,956	376,8	40,918	22,852
			Humic Acid (+)	44,156	11,378	20,328	61,984	3,104	321,8	29,842	408,2	40,938	23,106
			Mic. Fer. (-)	44,559	10,991	16,184	52,803	3,273	276,4	28,987	342	40,615	22,88
			Mic. Fer. (+)	44,428	11,662	20,65	63,15	3,12	332,6	29,811	443,1	41,242	23,078
			PR0	39,988	10,5	15,244	52,988	3,518	271,3	28,468	345,9	40,578 ab	21,929 b
			PR1	44,506	11,658	20,819	60,356	2,944	311,4	29,139	392,1	41,776 a	23,748 a
			PR2	46,488	11,381	20,344	67,875	3,341	325,2	30,683	414,3	41,035 ab	23,113 a
			PR3	46,994	11,767	17,263	50,688	2,984	310	29,306	417,7	40,320 b	23,126 a
	ANOVA		Humic Acid (A)	*	ns	*	*	ns	**	**	**	ns	ns
			Mic. Fer. (B)	ns	*	**	**	ns	**	**	**	ns	ns
			A x B	**	**	*	ns	*	*	ns	ns	ns	ns
			Phosp. Rock (C)	**	**	**	**	**	**	**	**	**	*
			A x C	**	**	**	**	ns	**	**	**	ns	ns
			B x C	**	**	**	ns	*	**	**	**	ns	ns
			A x B x C	**	**	**	**	**	**	**	**	ns	ns

Year	Treatments			Plant Height (cm)	First Pod Height (cm)	Number of Pods per Plant	Number of Seeds per Plant	Number of Seeds per Pod	Seed Yield (kg/da)	Harvest Index (%)	Biological Yield (kg/da)	Hundred-Seed Weight (g)	Seed Protein Ratio (%)
2016	Humic Acid (-)	Microbial Fertilizer (-)	PR0	48,00 c	10,25 d	14,57 b	33,11 bc	2,28	133,0 b	34,58 b	251,5 b	38,000 b	25,325
			PR1	51,75 b	11,75 c	15,88 ab	35,22 ab	2,23	156,0 a	33,10 b	316,1 a	40,750 a	25,37
			PR2	52,50 ab	12,75 b	15,98 ab	35,41 a	2,23	158,8 a	38,08 a	258,5 b	39,750 a	25,725
			PR3	54,00 a	13,50 a	16,85 a	32,29 c	1,92	157,0 a	37,88 a	257,5 b	39,563 a	25,918
		Microbial Fertilizer (+)	PR0	49,00 b	11,50 bc	14,65	34,68	2,38	147,5 c	38,50 b	235,7	39,500 b	25,003
			PR1	49,25 b	13,25 a	15,55	36,01	2,32	158,0 b	39,65 ab	240,5	40,800 a	25,135
			PR2	48,75 b	12,00 b	16,35	36,21	2,22	165,3 b	39,60 b	253,4	40,625 ab	25,253
			PR3	51,75 a	11,25 c	16,7	36,08	2,17	179,8 a	42,25 a	245,3	40,188 ab	25,488
	Humic Acid (+)	Microbial Fertilizer (-)	PR0	52,75 b	13,00 c	18,05	39,28	2,18	178,5 b	39,38 b	274,9 ab	41,875	24,648
			PR1	53,00 b	13,50 bc	16,87	41,13	2,46	181,0 b	41,58 ab	254,3 b	42,042	25,118
			PR2	55,00 a	13,75 ab	17,26	40,25	2,35	202,3 a	42,60 a	274,8 ab	41,208	25,36
			PR3	55,25 a	14,25 a	17,21	35,51	2,07	196,3 a	40,33 ab	291,0 a	41,083	25,355
		Microbial Fertilizer (+)	PR0	48,50 c	10,00 c	17,17 c	39,03 c	2,29	181,0 d	37,83 c	297,8 a	41,708 c	24,503
			PR1	49,00 c	13,00 b	18,59 bc	41,27 b	2,23	203,5 c	45,80 b	241,0 bc	43,750 a	24,818
			PR2	51,75 b	13,25 b	20,19 b	43,44 a	2,15	220,5 b	49,20 a	227,7 c	43,292 ab	24,943
			PR3	55,00 a	14,50 a	22,84 a	45,02 a	1,98	232,8 a	47,33 ab	259,2 b	42,083 bc	24,985
	General Means		Humic Acid (-)	50,63	11,96	15,815	34,874	2,216	156,8	37,953	257,3	39,897	25,402 a
			Humic Acid (+)	52,34	13,07	18,523	40,616	2,214	199,4	43,003	265,1	42,13	24,966 b
			Mic. Fer. (-)	52,74	12,76	16,584	36,523	2,214	170,2	38,438	272,3	40,534	25,352
			Mic. Fer. (+)	50,23	12,27	17,754	38,967	2,216	186	42,519	250,1	41,493	25,016
			PR0	49,41	11,21	16,109	36,526	2,283 a	160	37,569	264,9	40,271	24,869 b
			PR1	50,69	12,68	16,722	38,406	2,306 a	174,5	40,031	263	41,835	25,110 ab
			PR2	51,93	12,84	17,445	38,825	2,238 a	186,5	42,369	253,6	41,219	25,320 a
			PR3	53,92	13,33	18,399	37,223	2,034 b	191,3	41,944	263,2	40,729	25,436 a
	ANOVA		Humic Acid (A)	**	*	**	**	ns	ns	**	ns	**	*
			Mic. Fer. (B)	**	*	*	*	ns	**	*	**	**	ns
			A x B	ns	*	*	ns	**	ns	ns	ns	ns	ns
			Phosp. Rock (C)	**	**	**	**	**	**	**	ns	**	*
			A x C	ns	**	ns	ns	ns	*	**	**	ns	ns
			B x C	*	**	*	**	ns	**	**	*	ns	ns
			A x B x C	**	**	*	**	ns	**	**	**	*	ns

Values followed by the same letters in each microbial fertilizers are not significantly different at $P \leq 0.05$ level. * and ** significant at $P \leq 0.05$ and 0.01 level, respectively; ns, not significant.

the first and 232.8 kg da^{-1} in the second year). Humic acid-treated plots had 12.05% and 27.17% greater seed yield than non-humic acid-treated plots in the first and second year of the experiments, respectively. Microbial fertilizer treatments increased seed yields by 20.33% and 9.28% in the first and second year of the experiments, respectively. Humic acid and microbial fertilizer treatments increased seed yields significantly. Seed yields of bean plants increased with increasing phosphorus doses. The greatest seed yield was obtained from HA + MF + PR4 treatment (Table 3). Wahid et al. [41] reported the greatest seed yield for humic acid + poultry litter + phosphate rock treatments. Sharma et al. [42] reported significant increases in yields with the combined use of phosphate rock and phosphate-solubilizing bacteria. Present findings comply with the results of Doğan et al. [31], Malik et al. [39], Erman et al. [37], Sharar et al. [29], El-Gizawy and Mehasen [34].

Greater harvest index values were observed in humic acid and microbial fertilizer-treated plots than in untreated plots in both years. In general, harvest index values increased with increasing phosphate rock doses, but the greatest value was obtained from PR2 doses (Table 3). Present findings comply with the results of Singh et al. [33].

With regard to biological yield, except for HA + MF interaction, all treatments yielded increasing values in the first year as compared to control groups. With increasing phosphate rock doses, the greatest biological yield (504.8 kg da^{-1}) was obtained from HA + MF + PR3 treatment (Table 3). Humic acid and microbial fertilizer-treated plots had significantly greater biological yields than untreated plots. In general, significant increases were observed in biological yields with increasing phosphate rock doses in the first year, but the differences in biological yield values of the treatments were not found to be significant in the second year. Humic acid treatments increased biological yields in both years of the experiments. Similarly, Shaaban et al. [27] reported increasing biological yields with humic acid and 10% NPK fertilizer as compared to untreated control group.

While the lowest hundred-seed weight was obtained from the control group without any treatments, the greatest value was obtained from HA + MF + PR2 treatment (Table 3). In general, humic acid and microbial fertilizer treatments increased hundred-seed weights. Both the single treatments and interactions increased hundred-seed weights as compared to control groups. Present findings on hundred-seed weights comply with the results of Doğan et al. [31], Malik et al. [39], Erman et al. [37], Sharar et al. [29], El-Gizawy and Mehasen [34].

Seed protein ratios varied between 20.540-24.275% in the first year and between 24.503-25.918% in the second year. With regard to seed protein ratios of phosphate rock doses, the lowest value was obtained from the PR0 dose in both years and the greatest value was obtained from PR1 dose in the first year and from PR3 dose in the second year, but the ratios obtained from the other doses were placed into the same statistical group (Table 3). As compared to control group, all treatments increased seed protein ratios. Haghighi et al. [43] reported increasing seed protein ratios with humic acid treatments. Chesti et al. [44] reported that organic and inorganic phosphorus sources significantly increased seed protein ratios of mung beans as compared to control group and phosphorus-solubilizing bacteria-treated plots had 8-13% greater protein ratios than the control plots. Zafar et al. [36] indicated that different phosphorus sources and plant growth-promoting bacteria significantly increased seed protein ratios as compared to control groups.

CONCLUSIONS

Present findings revealed that humic acid, microbial fertilizer and phosphate rock treatments significantly increased yield and yield parameters of dry beans. Especially for seed yields each treatment significantly increased seed yields as compared to control group without any treatments. In both years, the greatest yield was obtained from HA + MF + PR3 treatments. Therefore, this treatment could be recommended for high yields in both organic and conventional bean farming.

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