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Influence of FYM and inorganic fertilizers on growth and yield of isabgol (*Plantago ovata* Forsk)

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Abstract

A field experiment was conducted to assess the effect of inorganic fertilizers and organic manure on plant growth and seed quality of isabgol in a hot arid region. Plant growth parameters *viz*., plant height, number of tillers plant^{-1} and dry matter accumulation was significantly higher with NPK + FYM as compared to other treatments. Yield attributes such as spike length, number of spikes plant^{-1} and number of grains spike^{-1} were also significantly higher with NPK + FYM. Highest grain (13.40 q ha^{-1}) and straw (30.21 q ha^{-1}) yield was obtained with the application of NPK + FYM, which was at par with NPK + Zn. Application of NPK + FYM recorded the highest N, P and K contents. However, highest Zn content was observed with NPK + Zn. The highest protein content in grain (12.43%) and straw (5.13%) was found with the treatment NPK + FYM, which was at par with NPK + Zn. The results clearly showed that the application of inorganic fertilizers significantly increase isabgol yield, nutrient content and grain quality when applied with organic manure as compared to sole application of inorganic fertilizers.

Keywords: isabgol, inorganic fertilizers, FYM, nutrient content, protein content

Isabgol (*Plantago ovata* Forsk) has been used in medicines since ancient times, but it has only been cultivated as a medicinal plant in recent decades. It is a 10 cm - 45 cm short-stemmed annual herb belonging to the family *Plantaginaceae*. In India, Isabgol occupies 2.93 lakh ha area and contributes about 36% of total isabgol production of the world (Anonymous 2007) and is grown in the states of Gujarat, Rajasthan, Madhya Pradesh and Uttar Pradesh. Rajasthan is one of the leading states in the India and is mainly grown in Bikaner, Jalor, Jodhpur and Pali districts. The area of isabgol in Rajasthan is 158000 ha with 42900 tonnes production and 272 kg ha^{-1} productivity (Anonymous 2006). Randhawa *et al*. (1985) reported that an increase in the seed yield results from an increase in N application in Isabgol. In the *Tarai* area of India, the highest seed yield was recorded following the application of 40-80 kg ha^{-1} N (Singh & Nand 1988). Koul & Sareen (1999) pointed out that if the quantity

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of N applied increases from 0 to 50 kg ha^{-1}; it induces a reduction in both N concentration and the swelling factor of *Plantago* seeds. Further, Singh & Sharma (1995) reported that isabgol does not respond beyond 30 kg N ha^{-1} and 30 kg P_2O_5 ha^{-1}. In the light of these facts, this study was aimed at determining the effect of inorganic fertilizers and organic manure on isabgol yield and quality in a hot arid region of Rajasthan, India.

The experiment was conducted during *rabi* 2003–04 and 2004–05 at the Instructional farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner, which is situated at 28^o 01′N latitude and 73^o 22′E longitude and at an altitude of 234.7 m above MSL. The physico-chemical properties of the soil are presented in Table 1. The soil of the experimental field was loamy sand in texture

Table 1. Physico-chemical properties of the experimental soil

Soil parameters	Value
Sand (%)	89.20
Silt (%)	3.51
Clay (%)	7.20
Soil Texture	Loamy sand
ECs (dS m^{-1})	0.16
pH (1:2)	8.3
Organic carbon (%)	0.09
Available N (kg ha^{-1})	65.25
Available P (kg ha^{-1})	12.50
Available K (kg ha^{-1})	150.76
Available Zn (mg kg^{-1})	0.62

and alkaline in reaction with low organic carbon, available N and P and medium in available K. The seeds of isabgol (cv. RI-89) was sown in plots of 2.2 m × 3.0 m in a randomized block design in seven treatments and three replications with crop geometry (20 cm × 5 cm) on 16.11.2003 and 22.10.2004 during *rabi* 2003–04 and 2004–05. The treatment details were (T_1) N_{40} - 40 kg N ha^{-1} (T_2) $N_{40}P_{30}$ - 40 kg N ha^{-1} and 30 kg P_2O_5 ha^{-1} (T_3) $N_{40}K_{20}$ - 40 kg N ha^{-1} and 20 kg K ha^{-1} (T_4) $N_{40}P_{30}K_{20}$ - 40 kg N ha^{-1}, 30 kg P_2O_5 ha^{-1} and 20 kg K ha^{-1} (T_5) FYM_{10} - 10 tone FYM ha^{-1} (T_6) $N_{40}P_{30}K_{20}$ + Zn_5 - 40 kg N ha^{-1}, 30 kg P_2O_5 ha^{-1}, 20 kg K ha^{-1} and 5 kg Zn ha^{-1} (T_7) $N_{40}P_{30}K_{20}$ + FYM_{10} - 40 kg N ha^{-1}, 30 kg P_2O_5 ha^{-1}, 20 kg K ha^{-1} and 10 t FYM ha^{-1}. FYM (0.38% N, 0.17% P, 0.18% K and 0.89 mg kg^{-1} Zn) was applied just after layout, mixed thoroughly in plots before imposing the treatments. Zinc was applied in the form of $ZnSO_4$ at the time of sowing. Half dose of N was applied as a basal and remaining half was applied one month after sowing as top dressing. Full dose of P and K were applied at the time of sowing below the seed in furrows made with the help of hand hoe. Manual thinning, weeding and hoeing were done at one month after sowing to provide an ideal environment to the crop. A light irrigation was given immediately before sowing; however, six and seven irrigations were given as per requirement of the crop with the help of a sprinkler.

Five plants were selected and tagged randomly in each plot, plant height and number of tillers plant^{-1} were recorded. Dry matter of plants per meter row length was recorded at the time of harvest in each plot. The spike length of five tagged plants was measured from the base of the lower spikelet to the tip of the upper most spikelet. At harvest, in the month of April number of spikes plant^{-1} and number of grains spike^{-1} were recorded separately from tagged plants in each plot. The mean values of all the observations were worked out.

The grain and straw samples were collected separately from each plot, dried at 60°C for 48 h. Dry mass was ground in a stainless steel ball mill for nutrient analysis. N concentration in both seed and straw was estimated by modified Kjeldahl's method (Snell & Snell 1939). The P content was determined using the vanadomolybdophosphoric acid yellow colour method (Jackson 1973). K content was estimated with diacid mixture by using Flame photometer (Champaman & Pratta 1961). The Zn content was estimated with Atomic Absorption Spectrophotometer (Lindsay & Norwell 1978). Crude protein in grain and straw was computed by multiplying the N content with 6.25 (AOAC 1960). In order to test the significance of variation the data were statistically analysed as per procedure described by Panse & Sukhatme (1985). The critical differences were calculated to assess the significance of treatment means (P<0.05).

Data presented in Table 2 indicated that highest plant height was found with NPK + FYM (35.04 cm), which was 16.32%, 12.81%, 24.78%, 60.07%, 43.07% and 102.54% superior to FYM, NPK + Zn, NPK, NK, NP and N, respectively. NPK was 28.27%, 14.65% and 62.31% superior to NK, NP and N respectively. Highest tillers plant^{-1} was measured with the treatment NPK + Zn (7.50), which was at par with NPK + FYM and 15.38%, 25.00%, 31.06%, 66.66% and 125.22% higher than FYM, NPK, NP, NK and N, respectively (Table 2). The treatment FYM (6.50) and NPK were at par and FYM was 16.05%, 33.33% and 80.18% superior to NP, NK and N, respectively. Application of NPK + FYM resulted in significantly highest dry matter accumulation and was significantly superior to all, but was at par with NPK + Zn and NPK (Table 2). Effect of NPK + FYM was 14.52%, 29.85%, 24.30% and 52.48% superior to FYM, NK, NP and N, respectively. The effect of FYM was at par with NK and NP, but was 29.47% higher over N. Application of FYM in combination with NPK results in more nutrients released at an optimum rate which helps in maintaining continuous supply of nutrients to the plant. The greater availability of nutrients in soil due to integrated fertilizer application through inorganic and organic sources might possibly have enhanced meristematic activity leading to increased plant height and dry matter accumulation. These results are in close conformity with finding of Sutaliya *et al.* (2003).

Data on spike length as influenced by various treatments during both the years are presented in Table 3. Results of pooled analysis showed that treatment NPK had highest spike length, but was at par with NPK + FYM, NPK + Zn, NP and FYM. All these treatments registered a significant difference in spike length over application of N alone. The number of spikes per plant was significantly different among the treatments (Table 3). Results of pooled analysis show that highest number of spikes per plant

Table 2. Effect of fertility schedules on plant height, number of tillers and dry matter accumulation of *Plantago ovata*

Treatments	Plant height (cm)			Number of tillers plant^{-1}			Dry matter (g) meter row length^{-1}		
	2003–04	2004–05	Pooled	2003–04	2004–05	Pooled	2003–04	2004–05	Pooled
T_1- N_{40}	18.37	16.32	17.3	3.0	3.66	3.33	72.59	72.67	72.63
T_2- $N_{40}P_{30}$	23.47	25.52	24.5	5.0	5.33	5.17	84.39	88.88	86.64
T_3- $N_{40}K_{20}$	21.45	22.34	22.34	5.0	4.0	4.5	3.38	89.24	76.63
T_4- $N_{40}P_{30}K_{20}$	29.56	26.6	26.6	5.66	6.33	6.0	99.97	101.54	100.75
T_5- FYM_{10}	29.79	30.46	30.13	6.0	7.0	6.5	96.46	91.63	94.04
T_6- $N_{40}P_{30}K_{20}$ + Zn_5	30.88	31.25	31.06	8.0	7.0	7.5	111.9	108.2	110.05
T_7- $N_{40}P_{30}K_{20}$ + FYM_{10}	34.87	35.22	35.05	6.66	7.66	7.16	108.2	107.21	107.71
CD (P<0.05)	3.66	3.59	2.54	1.06	1.2	0.79	19.98	18.17	13.38

Table 3. Effect of fertility schedules on spike length, number of spike and number of grains of *Plantago ovata*

Treatments	Spike length (cm)			Number of spike plant^{-1}			Number of grains spike^{-1}		
Nutrient (kg ha^{-1})	2003–04	2004–05	Pooled	2003–04	2004–05	Pooled	2003–04	2004–05	Pooled
T_1- N_{40}	2.35	2.38	2.36	13.66	13.33	13.5	33.66	34.33	34.0
T_2- $N_{40}P_{30}$	3.37	3.5	3.44	17.66	19.33	18.5	43.33	43.33	43.33
T_3- $N_{40}K_{20}$	21.9	3.47	3.29	15.0	19.0	17.0	42.66	42.33	42.50
T_4- $N_{40}P_{30}K_{20}$	28.08	3.58	3.34	21.66	22.0	21.83	47.0	45.00	46.00
T_5- FYM_{10} (10 t ha^{-1})	3.32	3.27	3.30	21.0	21.0	21.8	51.66	51.33	51.49
T_6- $N_{40}P_{30}K_{20}$ +Zn_5	3.4	3.47	3.44	23.66	23.66	23.66	54.33	52.00	53.16
T_7- $N_{40}P_{30}K_{20}$ + FYM_{10} (10 t ha^{-1})	3.2	3.52	3.36	24.33	23.66	24.0	53.66	49.66	51.66
CD ($P<0.05$)	0.56	0.49	0.37	4.86	5.41	3.6	7.86	8.43	5.71

was recorded with NPK + FYM, which was at par with FYM, NPK + Zn and NPK. Effect of NK, NP and N treatments on number of spikes per plant was significantly lower by 29.16%, 22.91% and 43.75%, respectively compared to NPK + FYM. However, application of FYM increased the number of spikes plant^{-1} by 23.52% and 55.55% over NK and N, respectively. The number of grains per spike significantly varied due to different treatments (Table 3). The highest grains per spike (53.16) was noted under NPK + FYM and FYM which were at par with NPK + Zn. NPK + Zn was 15.56%, 25.08%, 22.68% and 56.35% higher over NPK, NK, NP and N, respectively.

Application of NPK + FYM and NPK + Zn significantly increased the number of spikes per plant, spike length and number of grains per spike as compared to N, NP, NK, NPK and FYM in both the years. The positive effect of combined nutrient application may be due to cumulative effect on growth and vigour of plants. The tillering behaviour of isabgol indicated that at the initial stage, tillers compete with main stem for nutrients and metabolites, while at later stage, they compete for light. Thus, greater uptake of nutrients provides less competition between main stem and tillers resulting in higher number of effective tillers with nutrient application. The improvement in yield attribute characters with balanced nutrient application are in close conformity with Singh (2000), Mann & Vyas (1999) and Repsiene (2001).

Data pertaining to grain yield of isabgol are presented in Fig 1. Data of pooled analysis showed that highest grain yield was obtained with the application of NPK + FYM (13.40 q ha^{-1}), which was at par with NPK + Zn. Application of NPK + FYM recorded an increase of 16.31%, 31.24%, 43.16%, 58.01% and 80.10% over NPK, FYM, NP, NK and N, respectively. Similarly, application of NPK produced significantly higher yield by 12.83%, 35.84%, 23.07% and 54.83% over FYM, NK, NP and N, respectively. Effect of FYM on grain yield was at par with NP but was higher by 20.40% and 37.23% over NK and N, respectively. Higher straw yield (30.21 q ha^{-1}) was also obtained in

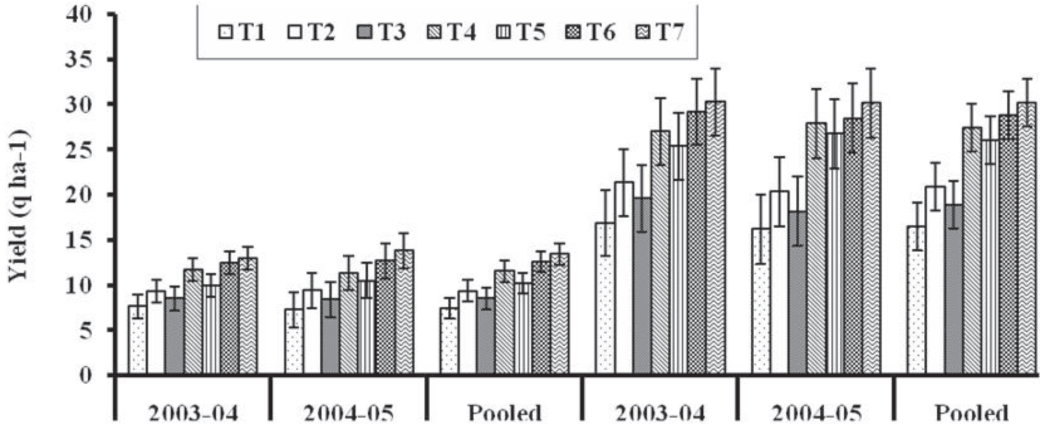

Fig. 1. Effect of fertility schedules on grain and straw yield of *Plantago ovata* [bars represent CD (P<0.05)]

the treatment NPK + FYM, which was at par with NPK + Zn and 15.79%, 10.13%, 60.26%, 44.68% and 82.75% higher over FYM, NPK, NK, NP and N, respectively. Effect of NPK and FYM on straw yield was at par with each other. However, application of NPK increased the straw yield by 45.51%, 31.36% and 65.94% over NK, NP and N, respectively. Application of NP and NK recorded similar effects on straw yield but NP recorded an increase of 26.31% over N alone. Significant increase in grain and straw yield of isabgol with balanced nutrient application (NPK + FYM) might be due to improvement in yield attributing characters *viz.* number of spikes per plant, spike length, number of grains per spike and number of tillers per plant. The results are in close conformity with the findings of Repsiene (2001), Kumar *et al.* (2001), Sutalia *et al.* (2003), Kumawat (2003) and Singh *et al.* (2004).

Data presented in Fig 2 indicated that the N, P and K contents of isabgol grain varied significantly due to different fertility schedules. Application of NPK + FYM recorded the highest N content and increased by 7.33%, 6.36%, 4.29%, 2.37%, 2.15% and 3.32% over N, NK, NP, NPK, NPK + Zn and FYM, respectively. Further, treatments NPK + Zn, FYM and NPK were at par and NPK + Zn was 4.11%, 2.09%,

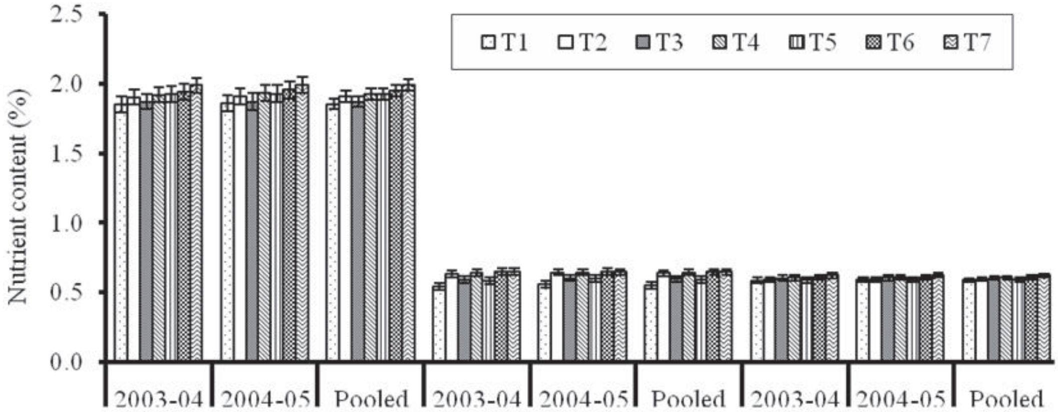

Fig. 2. Effect of fertility schedules on major nutrient content in grain of *Plantago ovata* [bars represent CD (P<0.05)]

and 5.07% higher over NK, NP and N, respectively. The highest P content was observed with NPK + Zn and NPK + FYM (0.647%), which was at par with NPK and NP. In case of K, NPK + FYM, contained highest K among all treatments. NPK + FYM treatment was 2.13%, 2.47%, 2.98%, 5.07%, 5.25% and 5.43% superior over NPK + Zn, NPK, NK, NP, FYM and N, respectively.

Fig. 3 showed that straw in NPK + FYM treatment contained highest N (0.821%) followed by NPK + Zn. Further, data showed that treatment NPK had N content of 0.792%, which was at par with FYM, NK and NP but 2.99% higher over N. The P content in straw was maximum (0.41%) with treatment NPK + FYM, which was at par with NPK + Zn and NPK treatments (Fig. 3). The treatment NPK + FYM contained highest K content (0.935%), which was 2.07%, 2.52%, 2.97%, 3.88%, 8.21% and 8.97% higher over NPK + Zn, FYM, NK, N and NP, respectively (Fig. 3).

The pooled data in Fig. 4 showed that the highest Zn content (44 ppm) in grain was found with the treatment NPK + Zn which was 8.02%, 9.65%, 11.04%, 8.48%, 8.95% and 8.20% higher than NPK + FYM, FYM, NPK, NK, NP and N, respectively. Fig. 4 also revealed that NPK + Zn treatment had highest Zn content (51.326 ppm) in straw, which was 5.37%, 6.89%, 7.42%, 7.54%, 8.94% and 9.33% superior over NPK + FYM, N, FYM, NP, NPK and NK, respectively. These results are in close conformity with the findings of Ramavtar (1995), Singh & Jat (2000) and Togay *et al.* (2004).

The data presented in Fig. 5 revealed that highest protein content in grain (12.43%) and straw (5.13%) were found with the treatment NPK + FYM, which was at par with NPK + Zn. The treatment NPK + FYM, significantly increased the protein content in grain over NPK + Zn, FYM, NPK, NP, NK and N by 2.22%, 3.32%, 3.32%, 4.36%, 6.42% and 7.34%, respectively in grain. However, it was 3.63%, 4.26%, 4.69%, 5.55% and 6.87% higher over NPK, FYM, NP, NK and N, respectively in straw. Thus, application of NPK + Zn increased protein content significantly compared to the application of N, NP, NK and NPK alone. These findings support the findings of Ramavtar (1995) and Gupta *et al.* (2001).

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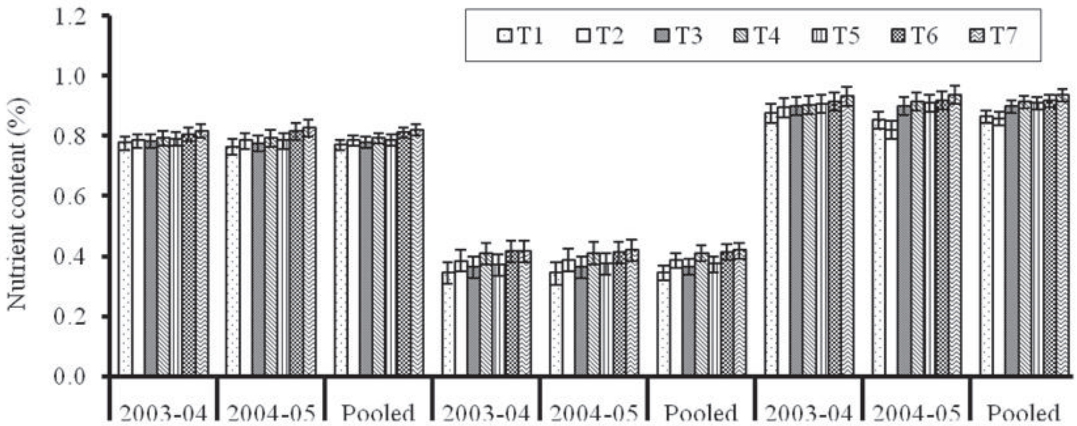

Fig. 3. Effect of fertility schedules on major nutrient content in straw of *Plantago ovata* [bars represent CD (P<0.05)]

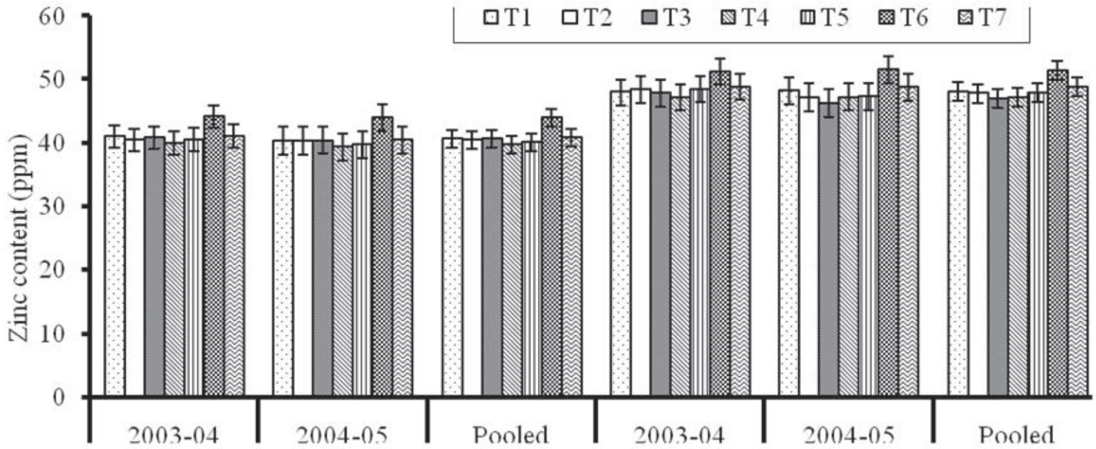

Fig. 4. Effect of fertility schedules on zinc content in grain and straw of *Plantago ovata* [bars represent CD (P<0.05)]

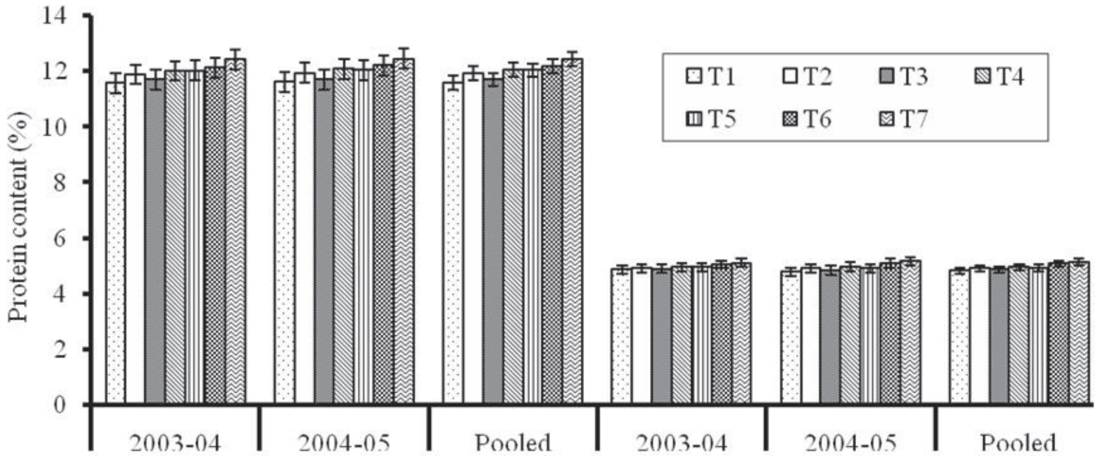

Fig. 5. Effect of fertility schedules on protein content in grain and straw of *Plantago ovata* [bars represent CD (P<0.05)]

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