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EFFECT OF VARIOUS LEVELS OF NITROGEN FERTILIZER ON THE YIELD AND YIELD ATTRIBUTES OF PEA (*PISUM SATIVUM* L.) CULTIVARS

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Abstract

A field experiment for two consecutive growing years (i.e., 1999-2000 & 2000-2001) was conducted on four pea cultivars viz., arkel, climax, green feast and olympia in response to different levels of applied N fertilizer under the climatic conditions of district Mastung, Balochistan. Fertilizer treatments (T_1 to T_7) were applied @ zero (control); 25; 50; 75; 100 and 125 kg N ha^{-1} plus a constant dose of P_2O_5 @ 60 kg ha^{-1} and K_2O @ 40 kg ha^{-1} in all treatments (except control). These N treatments were applied to each sub-plot (except T_1 and T_2) in two halves. The first one was applied at the time of initiation of flowering, while the 2nd one at the time of pod formation. Results showed that all mentioned components of pea cultivars (except pod length and protein contents) and most of their response toward applied rate of fertilizers were found highly significant ($P<0.01$). The maximum fresh pod yield $plant^{-1}$ (143.54 g), fresh pod yield ha^{-1} (11908.50), number of fresh pod $plant^{-1}$ (20.65), fresh pod length (9.06 cm), 1000 dry seed weight (240.13 g) and protein content (223.6 g kg^{-1}) of air dried seeds were recorded in fertilizer dose of 100+60+40 kg NPK ha^{-1}. Results also showed significant differences for all the parameters studied, and cultivar climax were found statistically at par in respect of above mentioned entries (except protein contents). It was further revealed that all mentioned attributes (except protein contents) were significantly ($P<0.05$) and positively correlated with fresh pod yield. Therefore, they can be used a suitable selection criteria for the yield in pea cultivars.

Introduction

The field or garden pea (*Pisum sativum* L.) of the family Papilionoideae is a cool season nutritive and vegetable crop. The crop is very much valuable in crop rotation (Duke, 1981). It is considered as an important cultivated legume next to soybean, groundnut and beans (Hules, 1994). Economically pea is predominant export and cash crop in world trade and represents about 40% of the total trading in pulses (Oram & Agcaoili, 1994).

In Pakistan peas are grown as winter crop in plains of all four provinces and also as summer crop in high lands. It is grown as rain-fed and irrigated crop. A recent investigation revealed that pea is an important vegetable, cultivated in Pakistan over 10,478 hectares with total production of 71,792 tons and with an average yield of 6.9 t hac^{-1}, and Punjab is the leading province, which contributes about 71% of the total production (Anon., 1999). The pea crop also occupies the third position among the major grain legume in Pakistan (Aslam *et al.,* 2000; Kazmi *et al.,* 2002). While in Balochistan province it is grown only in an area of 784 hectares, with total production of 8611 tons or 10983 kg ha^{-1} (Anon., 2002-2003). Pea also comes under the 3rd number in protein

content after garlic and beans. The different cultivars studied in the country almost contained 20-22% protein (Jabeen *et al.,* 1988), while Lukina (1990) has reported 24.3-26.6% protein in 158 cultivars of pea.

In Pakistan the cultivation and production of peas are very low as compared with most countries of the world. Some time country has to spend lot of foreign exchange to import pulses to meet the national food requirements (Aslam *et al.,* 2000). Therefore, there is a strong need to increase the yield of legumes in Pakistan. There are so many constrains which limits the crop production by reducing their growth and yield in the country. Out of which misuse of fertilizer and unavailability of improved varieties of seeds are the main hindering factors, which limits the economical crop growth. Although varieties of a crop may exist elsewhere, but differences in climate, soil, flowering and other agronomic factors may also affect their yield potential locally. Therefore, varieties may have to be tested for special local growing conditions (Hussain *et al.,* 2002). The soil of the study area is deficient in available nitrogen, need sufficient amount of additional nitrogen fertilizer for non-leguminous and small amount as starter dose for leguminous crops (Anon., 1994).

Subhan (1991) studied the effect of sowing time and method of nitrogen fertilizer application. He stated that a single application at sowing or split application, which included one at sowing time, increased the total number of pod plant^{-1}. Shah *et al.,* (2002) also found that N applied through broadcast method either in single or split doses gave statistically similar grain yield in mungbean. Amjad *et al.,* (2004) stated that seed yield and 1000 seed weight were significantly increased with increased level of P_2O_5 and K_2O applications up to the dose of 69+100 kg ha^{-1}, respectively. Although significant positive response of nitrogen fertilizer on the growth, yield and yield components of other legume crop has been thoroughly studied by many researchers (Ashraf, 2001; Mahboob & Asghar, 2002; Achakzai *et al.,* 2002a,b; Toğay *et al.,* 2005), but very little is known about the influence of nitrogen on the yield and yield attributes of pea under field conditions. However, maximum number of fresh pod plant^{-1} (33.10), pod length (8.49 cm), pod yield plant^{-1} (188.43 g) and total marketable green pod yield ha^{-1} (5.01 m.t) were recorded in plots with received 75+120+120 or 75+120+0 kg NPK ha^{-1}, respectively (Kakar *et al.,* 2002), while no advantage in pea plant stand on seed yield, or seed quality resulted from application of N and P fertilizers (Carr, 2000) and K_2O combined with P_2O_5 (Silva *et al.,* 1984). Several other researchers also revealed that combined application of NPK fertilizers have marked and significant effect on growth, yield and yield attributes of most of the crops than individual application of each nutrient. Prasad *et al.,* (1989), Brovkin & Bulato (1990) and Pochauri *et al.,* (1991) reported that combined application of NPK fertilizers gave significantly positive results of peas yield.

The plant yield is a dependent variable, depends upon all other growth and yield contributing traits. Therefore, it is generally correlated with all other components of yield. A highly significant and positive correlation ($P<0.01$) were found between fresh pod yield plant^{-1}, number of pods plant^{-1} and average pod weight, length and width of eight local cowpea genotypes (Peksen, 2004). Vahdettin *et al.,* (2004) also recorded positive and significant relationships ($P<0.05$) among seed yield, biological yield, harvest index, number of pods plant^{-1} and number of seeds plant^{-1}, but negative and non-significant relationship was determined between seed yield and seed weight. Many other researchers also noted significant and positive correlation among seed yield of other

legume crops with most of their growth and yield contributing parameters (Khan *et al*., 1983; Khan *et al*., 2000a,b; Achakzai & Kayani, 2004). The present study was therefore, mainly envisaged to evaluate the beneficial effect of varying levels of applied nitrogen fertilizer on the yield, yield components of and protein contents of four pea cultivars under the existing climatic conditions of district Mastung. The study was also furnished to select suitable dose of nitrogen fertilizer as well as variety response in maximizing their fresh pods yield.

Materials and Methods

Field experiment was conducted at district Mastung (situated 30 km south of provincial capital, Quetta). The experiment was initiated during winter (rabi) season for two consecutive years i.e., 1999-2000 and 2000-2001. The experimental plots were laid out in a randomized complete block design (RCBD). Four dwarf and early maturing varieties of pea viz., arkel, climax, green feast and olympia were grown in the experimental plot. The sub-plots were prepared and experiment was arranged in three replicates having plot size of 5 x 15m^2. Before sowing, a constant dose of phosphorus (P_2O_5) in the form of triple super phosphate (TSP) and potassium (K_2O) in the form of potash @ 60 + 40 kg ha^{-1} were applied to each sub-plot (except control T_1). The pre-soaked seeds were sown in rows by hand, keeping 50 and 25cm inter and intra spacings, respectively. The varying doses of nitrogen fertilizer @ 25, 50, 75, 100 and 125 kg ha^{-1} in the form of urea were applied to each sub-plot (except T_1 and T_2) in two halves. The 1st one was applied at the time of initiation of flowering, while the 2nd one at the time of pods formation. These nitrogen doses were latter on designated as T_3, T_4, T_5, T_6, and T_7, respectively. Three pickings of fresh pods were made during the course of study. For this purpose, five plants were randomly selected from each variety and each fertilizer treatment (sub-plot). Following data were collected on fresh yield and yield components:- (1) Pods weight $plant^{-1}$. (2) Pods weight ha^{-1}. (3) Number of pods $plant^{-1}$. (4) Pods length, cm. (5) 1000 seed weight, g. (6) Protein contents, g kg^{-1}. For protein analysis, five other randomly and physiologically matured plants were selected from each variety and sub-plot. The air-dried seed powder was then analyzed for their protein contents following the procedure of Bradford (1976). For this purpose absorbance was measured at 595 nm using Spectrophotometer (Hitachi U-1100, Japan). The bovine serum albumin was used as a standard to make standard calibration curve for seed protein estimation.

Data obtained were statistically analyzed, following the procedure as described by Steel & Torrie (1980). MSTAT-C computer software package was used and correlation coefficient studies were also made following the procedure described by Fisher & Yates, (1953).

Results and Discussion

Data presented in Table 1 showed that all mentioned components of pea cultivars (except pod length and protein contents) and most of their response toward fertilizers treatment were statistically found highly significant ($P<0.01$). However, interaction between varieties and fertilizer were generally found non-significant (except pod weight and pod length $plant^{-1}$).

Table 1. Analysis of variance (ANOVA) for yield and yield attributes of pea (*Pisum sativum* L.) cultivars in response to different levels of applied nitrogen fertilizer.

Variables	Sum of Squares		Mean Squares		F-Value of Variables		
	Variety (V)	Fertilizer (F)	Variety (V)	Fertilizer (F)	Variety (V) (Df=3)	Fertilizer (F) (Df=6)	V x F (Df=18)
1. Pods weight plant^{-1}.	2380.994	152666.650	793.665	25444.442	9.6880**	354.3910**	2.6627**
2. Pods weight ha^{-1}.	150594560.286	771918470.905	50198186.762	128653078.484	1.4399*	3.6463*	0.9941ns
3. Number of pods plant^{-1}.	303.708	6880.344	101.236	1146.234	12.2951**	246.8727**	3.4137**
4. Pods length plant^{-1}, cm.	0.169	152.708	0.056	25.451	0.7514ns	219.4068**	1.5372ns
5. 1000 seed weight, g.	8464.023	10844.632	2821.341	1807.439	34.2519**	58.8107**	3.0243ns
6. Protein contents, g kg^{-1}.	0.988	85.103	0.329	14.184	0.9133ns	15.5892**	0.9523ns

* and ** are slightly and highly significant at $P<0.05$ and $P<0.01$, respectively. While ns stands for non-significant at both probability levels.

Table 2. Effect of various levels of nitrogen fertilizer on the fresh pods yield plant^{-1} (g) of four cultivars of pea (*Pisum sativum* L.).

Fertilizer treatments	N:P: K (kg ha^{-1})	Arkel	Climax	Green feast	Olympia	Means
T_1	0:0:0	44.08	47.31	42.62	37.12	42.78 f
T_2	0:60:40	46.93	53.08	49.23	47.29	49.13 e
T_3	25:60:40	68.95	69.88	68.17	61.35	67.08 d
T_4	50:60:40	93.82	99.19	91.04	80.96	91.25 c
T_5	75:60:40	117.35	130.95	106.82	98.03	113.29 b
T_6	100:60:40	145.74	154.31	146.34	127.78	143.54 a
T_7	120:60:40	115.82	125.00	120.68	106.31	116.95 b
Means		90.38 b	97.10 a	89.27 b	79.83 c	89.14

Means followed by the same letters are statistically not significantly different at 5% LSD.
CV = 8.08%, LSD 5% = 6.83 for varieties and LSD 5% = 6.95 for fertilizers.

Table 3. Effect of various levels of nitrogen fertilizer on the fresh pods yield ha^{-1} (kg) of four cultivars of pea (*Pisum sativum* L.).

Fertilizer treatments	N:P: K (kg ha^{-1})	Arkel	Climax	Green feast	Olympia	Means
T_1	0:0:0	3433.33	3714.67	3624.33	3494.33	3566.66 f
T_2	0:60:40	3585.00	3815.33	3893.68	3581.68	3718.92 e
T_3	25:60:40	5625.67	3956.33	5344.68	5186.00	5028.17 d
T_4	50:60:40	8034.33	7898.68	7712.33	6805.68	7612.75 c
T_5	75:60:40	10318.67	10739.68	10480.00	7898.00	9859.09 b
T_6	100:60:40	12213.33	13117.67	11867.68	10435.33	11908.50 a
T_7	120:60:40	9576.67	10177.68	9965.68	9962.59	9920.59 b
Means		7541.10 a	7645.72 a	7555.48 a	6766.19 b	7373.52

Means followed by the same letters are statistically not significantly different at 5% LSD.
CV = 73.54%, LSD 5% = 4459.00 for varieties and LSD 5% = 4876.00 for fertilizers.

Fresh pod yield (plant^{-1}/ha^{-1}): Pea yield was significantly affected by both varieties and applied N levels (Table 2 & 3). All N doses produced significantly greater yield as compared with control (T_1). These findings are also similar to the results obtained on pea by Kakar *et al.,* (2002) and on other legumes (Jefing *et al.,* 1992; Ladha *et al.,* 1993; Bahlo *et al.,* 1995; Rani & Kodandaramaiah, 1997; Ali *et al.,* 2000; Ashraf, 2001; Achakzai *et al.,* 2002a,b; Achakzai & Kayani, 2004), but in contradiction with Carr (2000). Statistically maximum fresh pod yield i.e., 143.54 g plant^{-1} and 11908.50 kg ha^{-1} was obtained in T_6 dose of applied N fertilizer, which is at par than those recorded (Anon., 2002-2003), but lesser than obtained by Kakar *et al.,* (2002). This might be due to their increased rate of applied P & K fertilizers (i.e., 120+120 PK kg ha^{-1}). However, by comparing the variety response, climax statistically and numerically out yielded by producing 97.10 g pod yield plant^{-1} and 7645.72 kg fresh pod yield ha^{-1}, followed by arkel, green feast and olympia, respectively. Research revealed that out of 11 cultivars, advanced lines of pea out yielded (2.3 tons ha^{-1}) the local cultivars including climax (1.87 tons ha^{-1}). While in the present study the pod yield of all 4 cultivars is at par than those 11 cultivars of pea discussed by Hussain *et al.,* (2002), but it found lower than those obtained by Habib & Zamin (2003) for climax cultivar of pea (4.78 tons ha^{-1}) and Peksen (2004) for G10 genotype of cowpea (110.23 g plant^{-1}).

Table 4. Effect of various levels of nitrogen fertilizer on the number of fresh pods plant^{-1} of four cultivars of pea (*Pisum sativum* L.).

Fertilizer treatments	N:P: K (kg ha^{-1})	Arkel	Climax	Green feast	Olympia	Means
T_1	0:0:0	11.84	13.16	13.13	13.23	12.84 d
T_2	0:60:40	12.46	13.58	13.23	13.23	13.12 d
T_3	25:60:40	13.59	14.93	14.67	14.67	14.46 c
T_4	50:60:40	16.17	16.95	15.72	15.72	16.14 c
T_5	75:60:40	18.72	20.52	16.74	16.74	18.18 b
T_6	100:60:40	21.19	22.76	19.34	19.34	20.65 a
T_7	120:60:40	18.24	19.74	17.81	17.81	18.40 b
Means		16.03 b	17.37 a	15.80 b	15.82 b	16.25

Means followed by the same letters are statistically not significantly different at 5% LSD.
CV = 4.35%, LSD 5% = 0.72 for varieties and LSD 5% = 0.59 for fertilizers

Table 5. Effect of various levels of nitrogen fertilizer on the fresh pods length (cm) of four cultivars of pea (*Pisum sativum* L.).

Fertilizer treatments	N:P: K (kg ha^{-1})	Arkel	Climax	Green feast	Olympia	Means
T_1	0:0:0	5.13	4.82	4.94	4.73	4.90 f
T_2	0:60:40	5.26	5.18	5.23	5.30	5.24 e
T_3	25:60:40	5.73	5.83	6.11	6.07	5.94 d
T_4	50:60:40	6.42	6.31	6.48	6.88	6.52 c
T_5	75:60:40	7.18	7.84	7.14	7.19	7.33 b
T_6	100:60:40	8.99	9.56	8.99	8.73	9.06 a
T_7	120:60:40	7.46	7.51	7.57	7.78	7.58 b
Means		6.59 a	6.72 a	6.63 a	6.67 a	6.65

Means followed by the same letters are statistically not significantly different at 5% LSD.
CV = 5.12%, LSD 5% = 0.21 for varieties and LSD 5% = 0.28 for fertilizers

Yield attributes

A. Number of fresh pods plant^{-1}: Significant increase with progressive increase in applied N fertilizer, and a maximum number of pods plant^{-1} was recorded in T_6 dose of fertilizer, beyond this dose a significant reduction was observed (Table 4). The same was also recorded by Kakar *et al.,* (2002), but their resultant figure (33.10 pods plant^{-1}) were quite greater than present value. This might be due to the use of increased application rate of P & K fertilizers. Whereas, variety means also showed significant response and cultivar climax took top position (17.37 pods plant^{-1}), while remaining cultivars were statistically found non-significant. Many other researchers also recorded variety responses in this regard, but present figure is at par than those obtained by Habib & Zamin (2003) for cultivar climax (i.e., 12.6 pods plant^{-1}), but found lesser than those recorded maximum for cultivar rondo (18.8 pods plant^{-1}) by Hussain *et al.,* (2002), whereas, present number is at par than the minimum number recorded by the same.

B. Fresh pods length (cm): Pod lengths were significantly increased with a linear increase in applied N fertilizer (Table 5). Maximum length was recorded in T_6 dose of fertilizer (9.06 cm), beyond this significant reduction was measured. Results are in

agreement with the findings of Kakar *et al.,* (2002), but our resultant pod length is at par as compared with their results (8.49 cm). This might be due to the use of increased N fertilizer (i.e., 100 kg ha^{-1}). On the other hand variety means did not exhibit any statistical differences. However, numerically cultivar climax once again stood at top position (6.72 cm). This figure is not in line with those noted by Hussain *et al.,* (2002) for the same climax cultivar (8.17 cm).

C. 1000 seed weight (g): Nitrogen alongwith constant dose of P & K fertilizers significantly affected 1000 grain weight (Table 6). Maximum grain weight i.e., 240.13 g was recorded in plots receiving T_6 dose of applied fertilizer. Variety means also deciphered significant differences, and cultivar climax numerically produced maximum seed weight (229.10 g), which is at par than those recorded by Hussain *et al.,* (2002) for the same climax cultivar (217.3 g).

Table 6. Effect of various levels of nitrogen fertilizer on the 1000 seed weight (g) of four cultivars of pea (*Pisum sativum* L.).

Fertilizer treatments	N:P: K (kg ha^{-1})	Arkel	Climax	Green feast	Olympia	Means
T_1	0:0:0	209.89	207.55	212.69	189.82	204.97 f
T_2	0:60:40	211.67	215.24	223.55	191.15	210.41 e
T_3	25:60:40	214.34	220.84	221.59	203.74	215.13 d
T_4	50:60:40	228.72	227.29	221.92	200.15	219.52 d
T_5	75:60:40	237.74	245.45	236.19	207.95	231.83 b
T_6	100:60:40	243.39	252.85	247.59	216.72	240.13 a
T_7	120:60:40	227.44	234.20	220.52	216.99	224.78 c
Means		224.74 a	229.10 a	226.29 a	203.77 b	220.96

Means followed by the same letters are statistically not significantly different at 5% LSD.
CV = 2.51%, LSD 5% = 6.85 for varieties and LSD 5% = 4.55 for fertilizers

Protein contents (g kg^{-1}): Data pertaining to seed protein contents depicted that early doses of fertilizer did not significantly influence it, but it showed significantly negative response by receiving maximum dose of fertilizer (T_7). Numerically maximum protein content (248.1 g kg^{-1}) was recorded for treatment receiving no fertilizer (T_1). The present findings are also in conformity with many researchers for other legumes (Khushwaha & Chandel, 1997; Sugimoto *et al.,* 1998; Achakzai & Kayani, 2002; Achakzai *et al.,* 2003). Whereas, variety means also reflect significant differences, and cultivar arkel numerically produced greater protein contents (232.3 g kg^{-1} or 23.23%). Research revealed that different cultivars studied in the country contained 20-22% protein. Therefore, the resultant figures of all four cultivars are at par than those reported by Jabeen *et al*., (1988), but are found lesser than those recorded by Lukina (1990) in 158 cultivars of pea.

Correlation: The correlation coefficient (r) studies revealed that yield attributes (viz., number of pods $plant^{-1}$, pod length and 1000 seed weight exhibited highly significant ($P<0.01$) positive correlation with yields $plant^{-1}$ and yield ha^{-1}. Data similar with the results obtained by Vahdettin *et al.,* (2004) for peas, Peksen (2004) for cowpeas and for other legumes (Khan *et al.,* 1983; Khan *et al.,* 2002a,b; Achakzai & Kayani, 2004). Therefore, for the improvement of yield the information of these direct and indirect

effects of yield attributes could provide a realistic basis for a successful breeding program. These attributes can also be used as suitable selection criteria for predicting the fresh pod yield and grain yield in peas. Whereas, statistically non-significant relationships were established among protein content, yield and yield attributes. These are in disagreement with the results enumerated by Achakzai & Kayani (2002) and Achakzai *et al.,* (2003).

Table 7. Effect of various levels of nitrogen fertilizer on the protein contents (g kg^{-1}) of dry seeds of four cultivars of pea (*Pisum sativum* L.).

Fertilizer treatments	N:P: K (kg ha^{-1})	Arkel	Climax	Green feast	Olympia	Means
T_1	0:0:0	250.8	248.5	253.3	240.1	248.1 a
T_2	0:60:40	237.3	239.0	248.4	235.2	239.9 a
T_3	25:60:40	239.7	232.4	220.8	230.0	230.7 a
T_4	50:60:40	227.3	224.9	227.1	230.8	227.5 a
T_5	75:60:40	225.9	230.1	228.6	235.8	230.1 a
T_6	100:60:40	226.7	223.8	219.3	224.8	223.6 a
T_7	120:60:40	218.7	211.7	218.8	209.5	214.6 b
Means		232.3 a	230.0 a	230.9 a	229.4 b	230.6

Means followed by the same letters are statistically not significantly different at 5% LSD.
CV = 4.13%, LSD 5% = 0.4531 for varieties and LSD 5% = 0.7830 for fertilizers.

Table 8. Correlation coefficient (r) studies of yield attributes and protein content of dry pea (*Pisum sativum* L.) seeds with their yield.

Variables	1	2	3	4	5	6
1. Number of pods plant^{-1}	1.000					
2. Average pods length, cm	0.908 *	1.000				
3. Fresh pods yield plant^{-1}, g	0.957 *	0.925 *	1.000			
4. 1000 seed weight, g	0.743 *	0.676 *	0.730 *	1.000		
5. Protein contents, g kg^{-1}	0.011 ns	0.024 ns	-0.011 ns	-0.038 ns	1.000	
6. Fresh pods yield, kg ha^{-1}	0.433 *	0.406 *	0.437 *	0.357 *	-0.096 ns	1.000

* is highly significant at P<0.01, while ns stands for non-significant at P< 0.05 and P< 0.01, respectively.

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