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Original article

Identification of operative dose of NPK on yield enhancement of desi and kabuli chickpea (*Cicer arietinum* L.) in diverse milieu

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ABSTRACT

The effect of fertilizer on yield and yield related traits studied in two consecutive years at two different locations. Three different doses of fertilizer (NPK) applied at the rate of 9:23:0, 18:46:12 and 27:69:25 respectively on sixteen chickpea, genotypes (Desi and Kabuli advance lines and commercial varieties). Data recorded for days to 50% flowering, plant height, primary and secondary branches, pods per plant, 100-grain weight and grain yield (kg/ha). In Desi chickpea highest grain yield (kg/ha) in both years was produced by advance line D-12026 and in Kabuli advance line K-70005 at Faisalabad location. Grain yield kg/ha had significant positive correlation with all the considered parameters except days to 50% flowering and days to 50% maturity. The treatment comparison manifested that fertilizer doses 9:23:0 enhanced grain yield. The high dose of fertilizer is not recommendable. The grain yield of Desi and Kabuli chickpea at two locations Pulses Research Institute (PRI) Faisalabad and GBRSS (Gram Breeding Research Sub Station) Kallurkot had significant variation. The grain yield (kg ha^{-1}) was significant high in research area of PRI, Faisalabad in both years. The NPK 9:23:0 found operative dose of fertilizer for chickpea.

1. Introduction

Chickpea (*Cicer arietinum L.)* is self-pollinated; rabi season legume crop belongs to family Fabaceae. There are two main types of chickpea i.e. Desi and Kabuli and are simply designated as brown gram and white gram. Among the pulses, chickpea have higher protein bioavailability (Kishore et al., 2017) and contained 18–25% along with iron and higher amount of water-soluble vitamins therefore known as substitute of meat (Khamssi, 2011). Chickpea plays a fundamental role in production of pulses in Pakistan as it is cultivated on 73% of the total area occupied by pulses and its contribution to the total pulses production is 76% (PBS, 2020). In Pakistan, during the 2019–2020 crop years, total area under chickpea was 0.940 MH and production was around 0.54MT (PBS, 2020), against an estimated consumption of 0.70 m tones (FAO, 2015). Total consumption of chickpea is higher than its production; therefore, Pakistan has to import chickpea to meet its consumption requirement. During year, 2019–2020 Pakistan has imported 0.029 MT chickpea by spending 2715.104 million rupees (PBS, 2020). The increase in chickpea production is pivotal priority and inevitable. Production enhancement related with different factors including time of sowing, good soil management, availability of water, disease and insect pest control, weed management and availability of nutrients. Application of fertilizers correlated with requirement of plant and availability nutrients in soil. In precision agriculture excess use of fertilizers are not recommendable. The excessive and unbalance application of fertilizers increases cost of production without increasing production (Joshi et al., 2016). Farmers are usually unaware of operative dose of fertilizers and use irregular doses of fertilizers both in type and in amount. This may lead to the depletion of soil nutrients status (Dibabe et al., 2007). Proper nutrient management is necessary for obtaining higher yield in chickpea (Joshi et al., 2016). The study conducted to test the effect of variable doses of fertilizer NPK on different genotypes of chickpea. The experiment conducted to identify operative dose of fertilizer and most responsive chickpea crop genotype to fertilizer.

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2. Material and methods

The field experiments conducted in two consecutive cropping years 2017–18 and 2018–19 at two different locations including Pulses Research Institute (PRI) Faisalabad and GBRSS (Gram Breeding Research Sub Station) Kallurkot. The experiment was based on three different basal dose of NPK (Nitrogen, Phosphorus and Potash) and the source was (DAP and Potash). Three different treatments of fertilizer applied as NPK 9:23:0, 18:46:12 and 27:69:25 respectively. The fertilizers were applied by broadcasting @ 4.6 kg DAP and zero potash, 9.2 kg DAP and 2.3 kg Potash, 13.8 kg DAP and 4.6 kg potash for 3 treatments respectively, at time of sowing. The treatments designated as D_1, D_2 and D_3. The sixteen chickpea genotypes used in which nine were Desi and seven were Kabuli Table 1. Two cultivated commercial Desi and Kabuli varieties (Bittal-16) and (Noor 2013) kept as check and other genotypes were advance lines of chickpea. The treatment combinations arranged in Split Plot design with three replications. A plot size of 2.40 m^2 (4 m $\times$ 0.60 m) maintained into two rows, keeping a distance of 30 cm between rows and 15 cm between plants. Sowing had done with the dibbler and proper plant protection measures adopted during cropping season. Weeds controlled by hand weeding as frequently as required. All agronomic practices other than the fertilizer factors kept uniform across all treatments. Two different climatic conditions observed at both locations. Faisalabad site has Sub tropical climatic condition and lies between latitude 31.4504° N and at a longitude 73.1350° E with an elevation of about 189 m from sea level. Kallurkot area has desert climate and lies between latitude32.15° N, and longitude 71.26° E with an elevation of about 191.08 m. Data recorded for days to 50% flowering, plant height (cm), primary branches, secondary branches, number of pods per plant, 100-grain weight and grain yield (kg/ha). The total documented data processed through analysis of variance (Steel et al., 1997) and further studies had done through correlation (Sneath and Sokal, 1973). The genotypic and phenotypic correlation calculated by using following formula.

The Genotypic $r = Covg12/\ (\sigma^2 g_1).(\sigma^2 g_2)^{1/2}$

Phenotypic $r = Covg12/\ (\sigma^2 P_1).(\sigma^2 P_2)^{1/2}$

3. Results

The analysis of variance experiment conducted in 2017–2018 presented in Table 2, indicated significant difference in all varieties, treatments and their interaction for days to 50% flowering, plant height, primary branches, secondary branches, number of pods per plant, 100 grain (g) weight and grain yield (kg/ha). The data recorded for the year 2018–2019 indicated significant differences in varieties, treatments and their interaction for all the considered parameters. The analysis of variance presented in Table 3. The mean values of all recorded parameters presented in Table 4 for year 2017–2018 and revealed, out of nine Desi chickpea genotypes D-12026 had produced highest grain yield followed by D-12034 and D-13022. The genotype D-03009 remained at the bottom and produced lowest grain yield. Among the Kabuli seven genotypes K-70005 indicated high grain yield followed by K-70008 and Noor-2009. The genotype K-01020 produced lowest grain yield among all genotypes. In the year 2018–19, experiment repeated and mean values of all considered parameters in three variable doses of fertilizers presented in Table 5. The Desi chickpea genotype D-12034 indicated peak value of grain yield (kg/ha) while genotype D-11017 indicated lowest grain yield (kg/ha). Among the Kabali chickpea, genotypes the results remained persistent and genotype K-70005 had highest value grain yield and K-01020 lowest value of grain yield. The correlation analysis indicated grain yield was significant and positively correlated with all the parameter except days to 50% flowering and days to 50% maturity Table 6 and Table 7 during both years. The comparison of treatments indicated that in D_1 the chickpea genotypes produced more grain yield then D_2 and D_3 repeatedly in both years Fig. 1 and Fig. 2. The comparison of treatments along with two locations presented in Fig. 3. The graphical comparison indicated that highest grain yield obtained at Faisalabad location with D_1 during year 2018–2019. The lowest grain yield kg/ha obtained in year 2017–18 at Kallukot location with D_3.

4. Discussion

Although Chickpea is a legume plant and has capability to fix, atmospheric nitrogen but application of nitrogen can increase grain yield (Yagmur and Digdem, 2011). Efficient use of phosphorus in early growth stages is important for root enlargement and seed development (Singh et al., 2018a,b). Number of pods, number of grain and grain weight increased due to application of potassium (Singh et al., 2018a,b). Potassium consumption also refines damages due to water stress and positively affects the grain of chickpea (Moghaddam et al., 2016). The impact of fertilizer on chickpea is considerable and plays their role in increasing grain yield. The operative dose of fertilizer was still under discussion. Therefore, the study conducted to check the effect of different doses of fertilizers on grain yield and yield related parameters of chickpea to identify operative dose of fertilizer. The study revealed very interesting results with fluctuating response of advance lines and commercial varieties to different doses of fertilizers. During both years, high dose of fertilizers had maximum number of days to flowering and days to maturity. During both years of experiment days to flowering and days to maturity increased D_2 and D_3. The results were in corroboration with (Pathak et al., 2012). The extra doses of nitrogen prolonged the vegetative phase (Rehman and Dunfu, 2018). The chickpea has determinate growth habit (Bicer, 2014). The prolonged vegetative growth phase delayed the flowering, ultimately delayed in maturity (Hussen et al., 2015). Due to cropping intensity farmers' demand early maturing short duration chickpea varieties (Shukla et al., 2010). The impact of high dose of fertilizers on chickpea genotypes was not satisfactory due to delayed in flowering and late maturity in respect to earliness (Janmohammadi et al., 2018). Moreover, the delayed in flowering and maturity did not increase the grain yield. The high dose of NPK did not remain very effective for crop period. The plant height is also a key factor in relation to yield (Kamithi et al., 2009). The long stem is also very effective for source and sinks mechanism. During vegetative phase leaves become source and transported sugars to stem produced during photosynthesis and stem works as sink. During

Table 1
Advance lines and check varieties of Desi and Kabuli chickpea.

Sr.NO	Var.	Sr.NO	Var.	Sr.NO	Var.	Sr.NO	Var.
1	D-11017	5	D-13023	9	Bittal-16	13	K-01020
2	D-12026	6	D-10039	10	K-01014	14	K-01019
3	D-12034	7	D-03009	11	K-70005	15	Noor-2009
4	D-13022	8	D-075–09	12	K-70008	16	Noor-2013

Table 2
ANOVA for 2017–2018.

SOV	DF	DTF50%	P.H	P.BR	SEC.BR	DTM	Pods/P	100 G.W	GY/P
Replications	2	0.63	0.8	0.5	0.8	0.4	0.7	0.6	0.06
Varieties	15	62.5**	138.8**	2.3*	11.5**	0.3	996**	24.4*	205.6**
Error	30	0.8	6.7	3.1*	2.2	1.3	4.1	0.6	0.7
Treatment	2	121.5**	138.1**	3.4*	21.4**	4.1	65.7**	32.9*	231.7**
V*Trt	30	13.9**	26.4	4.1*	21.9**	1.5	175.1**	32.5*	270.1**
Error	64	0.7	2.7	0.12	0.7	0.6	1.9	5.1	6.9

DTF50%: Days to 50% flowering. **P.H**: Plant height. **Pri.Br**: Primary branches. **Sec.br**: Secondary branches, **Pods/P**: Pods per plant. **DTM50%**: Days to 50% maturity.**100GW**: 100 grain weight.**GY/kg/ha**: Grain yield

Table 3
ANOVA for 2018–2019.

SOV	DF	DTF50%	P.H	P.BR	SEC.BR	DTM	Pods/P	100 G.W	GY/P
Replications	2	1.1	0.06	0.03	0.1	0.04	0.04	0.4	0.7
Varieties	15	43.4**	144.2**	2.5*	21.6**	1.6	547.3**	55.9**	998.4**
Error	30	2.02	1.02	3.1*	2.1	0.6	1.5	0.08	2.8
Treatment	2	77.7**	201.2**	2.6*	41.2**	1.9	684.4**	159**	743.7**
V*Trt	30	2.6**	31.5**	3.1*	33.04**	1.4	229.1**	25.5**	269.2**
Error	64	0.68	6.5	0.08	1.9	0.9	1.9	0.6	4.1

DTF50%: Days to 50% flowering. **P.H**: Plant height. **Pri.Br**: Primary branches. **Sec.br**: Secondary branches, **Pods/P**: Pods per plant. **DTM50%**: Days to 50% maturity.**100GW**: 100 grain weight.**GY/kg/ha**: Grain yield

Table 4
Mean Values of yield related traits in different fertilizer treatments in years 2017–2018.

Sr. No	Genotypes	Dose	DOF 50%	P.H	Pri.Br	Sec.br	Pods/p	DOM 50%	100GW (g)	GY (kg/ha)
1	D-12026	D1	99.1	66.5	4.1	7.9	79.8	145.2	28.2	2105
		D2	102.3	54.2	3.2	7.1	54.7	148.2	22.1	1555
		D3	108.4	46.1	2.8	5.2	53.2	150.3	20.2	1497
2	D-12034	D1	101.1	61.8	3.8	7.4	74.1	147.1	25.3	2084
		D2	105.1	61.5	3.2	6.1	68.1	151.2	21.1	1855
		D3	109.1	50.7	2.1	5.8	70.7	155.5	19.1	1756
3	D-13022	D1	100.2	59.5	3.2	7.1	65.1	152.2	24.1	2062
		D2	105.1	59.6	3	5.3	53.5	154.1	19.2	1895
		D3	108.2	49.3	2.4	4.1	41.8	157.2	16.2	1493
4	D-03009	D1	102.1	48.9	3.1	5.1	46.3	148.1	23.5	1842
		D2	103.1	45.2	2.2	4.9	39.7	154.1	20.7	1547
		D3	112.1	44.1	2.6	4.6	32.8	158.2	19.3	1334
5	K-70005	D1	95.1	67.0	4.5	9.4	77.6	145.3	23.1	1917
		D2	95.1	61.8	3.2	6.6	69.9	150.2	21.7	1834
		D3	105.2	53.3	2.8	7.8	47.7	145.1	17.7	1417
6	K-70008	D1	98.1	61.2	4.2	9.1	61.1	152.1	22.3	1842
		D2	101.1	60.7	2.8	7.1	56.9	155.2	20.1	1484
		D3	106.2	51.4	2.2	5.6	42.2	157.1	16.1	1204
7	Noor-2009	D1	98.1	58.1	4.1	9.2	65.1	150.1	21	1805
		D2	98.2	55.5	3.4	9.1	64.3	152.2	19.4	1605
		D3	108.3	50.3	2.1	7.2	37.8	155.3	17.5	1105
8	K-01020	D1	98.1	47.4	2.8	6.8	41.6	148.4	17.1	1437
		D2	100.5	43.7	2.5	5.7	35.9	153.1	16.4	1289
		D3	110.5	42.7	2.1	4.9	32.8	158.1	12.1	1000
		LSD	10.2	18.2	2.5	3.5	21.2	15.2	14.6	19.6

DTF 50%: Days to 50% flowering. **P.H**: Plant height. **Pri.Br**: Primary branches. **Sec.br**: Secondary branches, **Pods/P**: Pods per plant. **DTM50%**: Days to 50% maturity.**100GW**: 100 grain weight.**GY/kg/ha**: Grain yield

maturity stem transported all sugars to grains through phloem. In chickpea, moderate plant height is required (Erdemci, 2018). The tall chickpea plants are desirable in mechanical harvesting. The problem with tall plants is lodging, when crop is at maturity, which causes considerable yield losses (Ismail et al., 2017). In the studies, genotypes with tall plants produced highest grain yield in comparison with short plant genotypes. The increase in plant height observed with D_1, which was the indication of low dose of fertilizer. The medium or high dose of fertilizer did not show any impact on plant height (Singh et al., 2018a,b). The results indicated that impact of fertilizer on plant height is considerable (Sohu et al., 2015). The number of primary and secondary branches contributed directly in yield and yield related parameters. The number of pods is usually maximum on primary branches then secondary branches. The results manifested that in D_1 of fertilizer number of primary and secondary branches remained determined during both years. The increase in number of primary and secondary branches induced positive impact on total grain yield (Walley et al., 2004). The number of pods per plant is directly proportional to grain yield per plant. The increase in number of pods per plant ultimately increases in number of grain per plant. The D_1 of fertilizer enhanced number of pods per plant in both years and D_3 had lowest mean value of pods per plant. The number of pods per plant positively correlated with grain yield per plant (Sarvajeet et al., 2018). In two consecutive years 100-grain weight remained highest in D_1 and lowest in D_3. The results are clear indication of

Table 5
Mean Values of yield related traits in different fertilizer treatments in years 2018–2019.

Sr.No	Genotypes	Dose	DOF50%	P.H	Pri.Br	Sec.br	Pods/p	DOM 50%	100GW (g)	GY (kg/ha)
1	D-12026	D1	98.1	65.2	4.2	9.2	66.57	144.2	28.2	2434
		D2	101.1	56.1	2.8	7.1	55.3	152.1	25.1	2300
		D3	105.2	53.7	2.4	5.2	51.2	153.1	22.2	2050
2	D-12034	D1	99.1	63.4	3.9	8.2	56.3	145.2	27.2	2384
		D2	100.2	59.0	3.2	5.5	47.2	151.1	24.1	2367
		D3	103.2	54.4	2.1	5.1	45.2	154.2	22.1	2184
3	D-13022	D1	99.2	59.2	3.4	9.2	48.5	150.1	24.5	2151
		D2	101.1	56.1	3.6	7.4	42.6	153.2	23.3	2034
		D3	102.2	55.8	3.2	5.4	41.1	155.1	21.2	2018
4	D-11017	D1	101.1	46.2	2.4	7.6	40.8	150.1	18.1	1418
		D2	102.2	43.1	3.0	6.8	35.6	153.2	15.2	1384
		D3	106.1	41.8	2.2	4.1	32.8	156.1	14.1	1250
5	K-70005	D1	101.1	73.2	4.6	10.1	76.3	150.2	29.2	2285
		D2	103.2	68.1	3.2	7.6	72.0	153.1	27.1	1918
		D3	107.1	67.7	2.8	7.2	67.6	155.2	24.1	1901
6	K-70008	D1	98.2	72.6	3.8	8.2	62.0	150.1	27.5	2068
		D2	101.1	69.6	2.6	7.1	56.2	151.2	25.1	1684
		D3	105.1	62.8	2.2	6.4	51.6	154.1	22.2	1634
7	Noor-2009	D1	98.2	62.5	3.6	7.8	55.4	148.2	25.2	2034
		D2	99.5	60.8	3.2	7.4	53.2	152.1	23.1	1917
		D3	103.2	59.6	2.8	5.6	51.4	153.2	22.3	1868
8	K-01020	D1	102.1	48.7	2.5	6.8	37.0	152.5	19.1	1451
		D2	104.2.	45.8	2.2	5.6	35.4	152.1	18.5	1334
		D3	108.1	43.9	2.1	4.4	32.2	158.8	16.2	1218
		LSD	10.2	18.2	2.1	5.4	20.1	15.2	14.2	15.1

DTF50%: Days to 50% flowering. **P.H**: Plant height. **Pri.Br**: Primary branches. **Sec.br**: Secondary branches, **Pods/p**ods per plant. **DTM50%**: Days to 50% maturity.**100GW**: 100 grain weight.**GY/ kg/ha**: Grain yield.

Table 6
Genotypic (Upper diagonal) and phenotypic (Lower diagonal) correlation of yield related traits in erratic fertilizer treatments in years 2017–18.

	DTF50%	P.H	Pri.Br	Sec.br	Pods/p	DTM50%	100GW(g)	GY/kg ha^{-1}
DTF50%	1	−0.01	0.02*	0.01	−0.2	−0.01*	−0.02	−0.01
P.H	−0.01	1	0.2	0.1*	0.2*	0.2	0.1*	0.1*
Pri.Br	−0.1	0.4*	1	−0.1	0.01*	0.2*	0.1*	0.2*
Sec.br	0.02	0.01	0.03*	1	−0.2	−0.1	0.02*	0.1*
Pods/p	−0.01*	0.2*	0.01	0.05*	1	0.1	0.01*	0.1*
DTM50%	0.01*	0.04	0.05	0.05	0.02	1	−0.2*	−0.02*
100GW(g)	0.3*	0.2*	−0.3*	0.1*	0.4	0.2	1	0.3*
GY/P(g)	−0.01	0.3*	0.2*	0.1*	0.3*	−0.1*	0.1*	

Table 7
Genotypic (Upper diagonal) and phenotypic (Lower diagonal) correlation of yield related traits in erratic fertilizer treatments in years 2018–19.

	DTF50%	P.H	Pri.Br	Sec.br	Pods/p	DTM50%	100GW(g)	GY/ kg ha^{-1}
DTF50%	1	−0.03*	0.8*	0.09	−0.1	0.003*	−0.009*	−0.01
P.H	−0.02*	1	−0.2	0.1*	0.2*	0.2	−0.1*	0.1*
Pri.Br	0.8*	−0.5*	1	0.1	0.01	0.50*	0.67	0.2*
Sec.br	0.006	0.03*	0.02*	1	0.2*	0.2*	0.031	0.1*
Pods/p	−0.04*	0.03*	0.02	0.09*	1	0.2	0.019	0.1*
DTM50%	0.06*	0.02	0.03	0.04	0.01	1	−0.1	−0.02*
100GW(g)	0.5*	0.4*	−0.6	0.2*	0.6	−0.1	1	0.3*
GY/P(g)	−0.01	0.3*	0.2*	0.1*	0.3*	−0.1	0.1*	

non-responsive behavior of extra doses of NPK in chickpea. The grain yield (kg/ha) reflected that dose D_1 (9:23:0) is operative dose of fertilizer for both desi and kabuli chickpea and genotypes Desi D-12026 and Kabuli advance line K-70005 was more responsive to fertilizers in comparison with other genotypes. Phenotypic and genotypic correlation analysis revealed that grain yield had positive genotypic and phenotypic correlation with all yield and yield related parameters except days to 50% flowering and days to 50% maturity (Sharifi et al., 2018). The correlation values are same; it indicated very low impact of environment on grain yield in both years (Astereki et al., 2017). The comparison of treatments clearly showed D_1 had considerable impact on grain yield per plant. The comparison of locations indicated, the climate of Pulses Research Institute Faisalabad is more suitable for chickpea than climate of Gram Breeding Research Sub Station, Kallurkot. The studies indicated that D_1 of fertilizer NPK 9:23:0 enhanced yield and yield related parameters in both years 2017–2018 and 2018–2019.

5. Conclusion

Three different doses of fertilizers (NPK) applied with low, medium and high or extra dose on sixteen chickpea, Desi and Kabuli advance lines and commercial varieties as check. Data were recorded for days to 50% flowering, plant height (cm), primary and secondary branches, pods per plant, 100-grain weight (g) and grain yield (kg/ha). The highest grain yield (kg/ha) in both

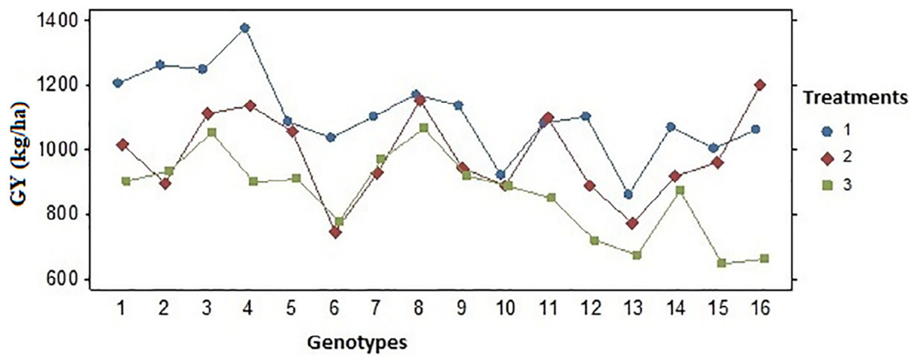

Fig 1. Comparison of different fertilizer treatments for grain yield (kg/ha) in year 2017–2018.

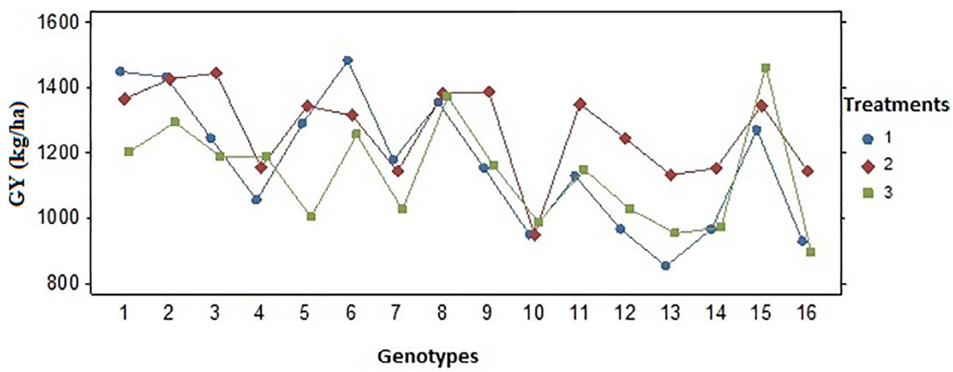

Fig 2. Comparison of different fertilizer treatments for grain yield (kg/ha) in year 2018–2019.

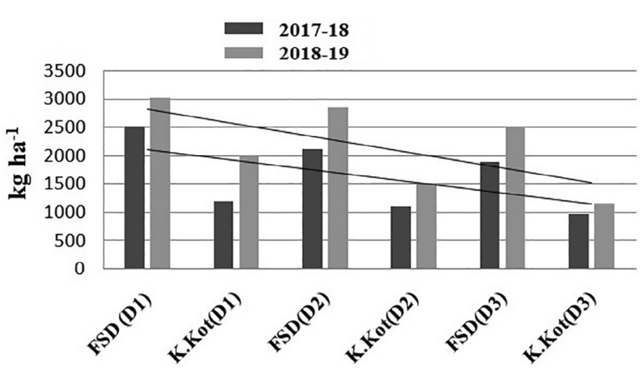

Fig 3. Comparison of grain yield (kg/ha) at two different locations with different doses of fertilizers in years 2017–2018 and 2018–2019.

years was produced by Desi advance line D-12026 and in Kabuli advance line K-70005 at Faisalabad location. The treatment comparison manifested that low doses of NPK fertilizers enhanced grain yield. The high dose of fertilizer is not recommendable. The grain yield of Desi and Kabuli chickpea at two locations Pulses Research Institute (PRI) Faisalabad and GBRSS (Gram Breeding Research Sub Station) Kallurkot had significant variation, elaborating the impact of climate on yield. The grain yield (kg ha^{-1}) was significant high in research area of PRI, Faisalabad with D_1 of fertilizer.

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