GROWTH RESPONSE AND ECONOMICS VARIABILITY IN HYBRID PIGEONPEA TO NITROGEN AND PHOSPHORUS FERTILIZATION

ABSTRACT

A field experiment was conducted on deep black cotton soils of Regional Agricultural Research Station, Lam during *kharif* season, 2018-19 in hybrid pigeonpea (ICPH-2740) to study the growth response and economic variability in hybrid pigeonpea to nitrogen and phosphorus fertilization. The experiment was laid out in factorial randomized block design comprised of four levels of nitrogen (N_1: 20 kg ha^{-1}, N_2: 40 kg ha^{-1}, N_3: 60 kg ha^{-1}, N_4: 80 kg ha^{-1}) and three levels of phosphorus (P_2O_5) (P_1: 50 kg ha^{-1}, P_2: 75 kg ha^{-1}, P_3: 100 kg ha^{-1}). The higher values of grain yield (1900 kg ha^{-1} & 1833 kg ha^{-1}), net returns (Rs.60522/- & Rs.57181/-) and B:C ratio (1.62 & 1.54) were found with application of nitrogen (60 kg ha^{-1}) and phosphorus (75 kg ha^{-1}), respectively. It was concluded that in Krishna agro-climatic zone of Andhra Pradesh, an application of 60 kg N ha^{-1} and 75 kg P_2O_5 ha^{-1} was applied for getting economically higher grain yield in hybrid pigeonpea.

Key Words: *ICPH-2740, Growth response, Economics, Nitrogen and Phosphorus*

INTRODUCTION

The pigeon pea (*Cajanus cajan*) is a perennial legume from the family Leguminaceae (Fabaceae). It is also known as Pigeonpea or Tur or Arhar. Since its domestication in India at least 3,500 years ago, its seeds have become a common food grain in Asia, Latin America and Africa. On a large scale, it is consumed mainly in south Asia and is a major source of protein for the population of that subcontinent. Pigeonpea after Chickpea, is the second most important pulse crop in the country. India is the largest producer and consumer of Red gram in the world. India accounts for over ¾ of acreage and production of the globe.

"The crop is extensively grown in Maharashtra, Andhra Pradesh and Gujarat. Maharashtra has unique distinction of contributing about 30% of total pigeonpea production in the country. India is the largest producer of pigeonpea with 4.2 M t of production in an area of 4.4 M ha with an average productivity of 960 kg ha^{-1}. Whereas, in Andhra Pradesh the pigeonpea is grown in an area of 2.79 lakh ha with an average production of 1.19 lakh tonnes and productivity of 489 kg ha^{-1}" (Annual Report DPD, 2017-18). "Demand for pigeonpea in India is ever increasing and the scope for expansion is limited, therefore attention is now focused on increasing it's per unit productivity"[14,15,16]. "This can be achieved only by adopting a proven technology like hybrids. A beginning in this direction has already been made through the release of hybrid ICPH-2740. It is the first commercial pigeonpea hybrid released in Telangana state as "Mannem Konda Kandi" in 2015. This hybrid has demonstrated a significant yield advantage over the most popular cultivars in Andhra Pradesh and Telangana. In order to achieve higher yields, the adoption of optimum use of nutrient levels will go a long way in making efficient use of limited resources and thus to stabilize the productivity of pigeonpea. Adequate N supply is usually associated with increased yield and protein content in pigeonpea. Similarly, phosphorus is an important mineral nutrient for grain legumes as it helps in root development, nodulation, synthesis of phosphates and phosphoproteins and hastens maturity" (Tisdale et al. 1995). Combined supply of N and P could have synergistic effect on nutrient uptake and seed yield. In order to achieve higher yields, the adoption of optimum use of nutrient levels will go a long way in making efficient use of limited resources and thus to stabilize the productivity of pigeonpea, an experiment was conducted.

MATERIAL AND METHODS

A field experiment was conducted during *kharif*, 2018 on deep black cotton soils at Regional Agricultural Research Station-Lam Farm, Guntur, which is situated at an altitude of 35.1 m above mean sea level, 16º2ˈN latitude, 80º3ˈE longitude in Krishna Agro Climatic Zone of Andhra Pradesh, India. Based on soil analysis, the soil of the experimental site was classified as clay in texture, alkaline in reaction, low in organic carbon (0.43%), low in nitrogen (188 kg ha^{-1}), medium in phosphorus (43.5 kg ha^{-1}) and high in potassium (716 kg ha^{-1}). The experiment was laid out in factorial randomized block design comprised of four levels of nitrogen (N_1: 20 kg ha^{-1}, N_2: 40 kg ha^{-1},N_3: 60 kg ha^{-1}& N_4: 80 kg ha^{-1}) and three levels of phosphorus (P_2O_5) (P_1: 50 kg ha^{-1}, P_2: 75 kg $ha^{-1}$and P_3: 100 kg ha^{-1}) of hybrid pigeonpea ICPH-2740. Basal application of nitrogen and phosphorus was done as per the treatments. The crop was sown on 17th July, 2018 with a row spacing of 180 cm and plant to plant spacing of 20 cm. The cumulative precipitation received during the crop growth period was 391.1 mm in 21 rainy days. The data was collected in five plants selected randomly from each treatment. The crop was harvested on 12th January, 2019. By using standard statistical procedures, the data collected were analyzed. The comparison of treatment means was made by critical difference (CD) at $P \leq 0.05$.

RESULTS AND DISCUSSIONS

GROWTH PARAMETERS

Data related to the growth parameters was tabulated in the Table 1. Highest plant height was noticed with application of 80 kg N ha^{-1}. The plant height of 232.4 cm was obtained with the highest nitrogen level (80 kg N ha^{-1}) which was significantly on par with 60 kg N ha^{-1} registering 227.5 cm at harvest. The enhancement in the plant height with increment in nitrogen level might have accelerated the synthesis of more chlorophyll and amino acids and stimulated the cellular activity, responsible for cell division and meristematic growth. These results were in close conformity with those of Goud *et* al. (2012), Meena *et al.* (2013), Singh *et al.* (2016), Ramanjaneyulu *et al.* (2017).

With an increase in levels of phosphorus, significant increase in plant height was observed. The plant height of 230.6 cm was recorded highest with an application of 100 kg P_2O_5 ha^{-1} and was on par with 75 kg P_2O_5 ha^{-1} (223.4 cm) and superior over 50 kg P_2O_5 ha^{-1}. The increase in plant height due to higher levels of phosphorus might be due to accelerating effect of P on the synthesis of protoplasm, and role of P in growth of new tissues and cell elongation which in turn increases the plant height. Similar outcomes were reported by Goud *et al*. (2012), Kumar *et al*. (2012) and Ade *et al*. (2018).

There was a significant improvement in the drymatter production at harvest with an increase in N levels. The highest drymatter accumulation of 7347 kg ha^{-1} was recorded with an application of 80 kg N ha^{-1} which was on par with 60 kg N ha^{-1} (7052 kg ha^{-1}). However, the drymatter accumulation was significantly higher with 80 kg N ha^{-1} than that of other two lower levels of nitrogen (20 kg ha^{-1} and 40 kg ha^{-1}) at harvest. The probable reason for increase in the drymatter accumulation with increase in the nitrogen level might be due to its role in plant metabolism by being an essential constituent of metabolically active compounds like amino acids, nucleic acids and enzymes. Thereby it resulted in an increase in the photosynthetic activity which finally resulted in vegetative growth. Increase in drymatter with increase in nitrogen levels was supported with earlier findings by Meena *et al*. (2013), Ramanjaneyulu *et al.* (2017) and Sultana *et al*. (2018).

The application of 100 kg P_2O_5 ha^{-1} registered highest drymatter accumulation at harvest *i.e.*, 7213 kg ha^{-1} and was found significantly superior over 50 kg P_2O_5 ha^{-1} but was not comparable with 75 kg P_2O_5 ha^{-1}. This might be due to the beneficial effect of phosphorus attributed towards root proliferation, nodulation and synthesis of protoplasm and gave higher pace of drymatter accumulation. The results are in similar trend with those of Aher *et al.* (2015) and Ade *et al*. (2018).

Higher number of nodules plant^{-1} was recorded with 80 kg N ha^{-1} (21.6) than that with 60 kg N ha^{-1} (19.7) at 90 DAS but the difference between these two levels was not significant. Similar trend of influence was noticed at lower levels of nitrogen 20 kg ha^{-1} and 40 kg ha^{-1}. Increasing nitrogen level might have increased number of nodules plant^{-1} due to increase in carbohydrates and energy supply to root as well as to the nodulating bacteria which resulted in higher nitrogen fixation as reported by Singh *et al*. (2016).

Increment in phosphorus levels showed significant difference in the number of nodules plant^{-1}.The maximum number of nodules plant^{-1} (20.8) were recorded with higher level of 100 kg P_2O_5 ha^{-1} which was on par with 75 kg P_2O_5 ha^{-1} (19.2) but it was significantly superior than that of 50 kg P_2O_5 ha^{-1}. With addition of successive doses of phosphorus, the nodules plant^{-1} increased as phosphorus helps the plant to provide favourable conditions for nodulation. (Ade *et al*., 2018).

Application of 80 kg N ha^{-1} increased the number of primary (14.2) and secondary branches plant^{-1} (39.0) significantly higher than that of 40 kg N ha^{-1} and 20 kg N ha^{-1} and it was on par with 60 kg N ha^{-1} (13.5 and 37.0, respectively). The lowest number of primary branches plant^{-1} and secondary branches plant^{-1} were observed with an application of 20 kg N ha^{-1} which was on par with that of 40 kg N ha^{-1}. Increasing nitrogen levels increased the photosynthetic activity of pigeonpea plant which naturally accounted for higher number of primary and secondary branches plant^{-1}. Similar results were found with Singh *et al*. (2016) and Sultana *et al*. (2018).

Table 1: Influence of nitrogen and phosphorus levels on the growth parameters of hybrid pigeonpea (ICPH-2740)

Treatments	Plant height (cm)	Drymatter accumulation (kg ha^{-1})	Number of nodules plant^{-1}	Number of branches plant^{-1}	
				Primary branches	Secondary branches
Nitrogen levels (kg ha^{-1})					
20	207.4	6068	16.0	10.8	28.3
40	210.2	6413	18.2	12.0	32.8
60	227.5	7052	19.7	13.5	37.0
80	232.4	7347	21.6	14.2	39.0
SEm±	6.68	294.59	0.98	0.44	1.74
CD (p=0.05)	19.6	864	2.9	1.3	5.1
Phosphorus (P_2O_5) levels (kg ha^{-1})					
50	204.2	6218	16.6	11.5	30.8
75	223.4	6730	19.2	12.8	35.0
100	230.6	7213	20.8	13.6	37.1
SEm±	5.79	255.13	0.85	0.38	1.51
CD (p=0.05)	17.0	748	2.5	1.1	4.4
Interaction (N × P)					

SEm±	11.57	510.26	1.69	0.77	3.02
CD (p=0.05)	NS	NS	NS	NS	NS
CV (%)	9.1	13.2	15.6	10.5	15.3

YIELD ATTRIBUTES AND YIELD

The number of branches plant^{-1} were influenced significantly with different levels of phosphorus. Highest number of primary branches and secondary branches plant^{-1} were recorded with 100 kg P_2O_5 ha^{-1} (13.6 and 37.1) which was in turn not comparable with 75 kg P_2O_5 ha^{-1} (12.8 and 35.0) and the least was recorded with 50 kg P_2O_5 ha^{-1}. This increase in the number of branches plant^{-1} might be due to the reason that phosphorus improved the nutrient availability resulting in greater nutrient uptake which might have increased the photosynthesis and translocation of assimilates to different parts for enhanced growth of number of primary and secondary branches. These results are in close conformity with those of Goud *et al.* (2012) and Ade *et al*. (2018).

The improvement in the nitrogen levels from 20 to 80 kg N ha^{-1} showed significant difference in the seed yield. The highest seed yield of 1911 kg ha^{-1} was realised with 80 kg N ha^{-1} than that of other levels of nitrogen (Table 2). However, the difference between 80 kg N ha^{-1}& 60 kg N ha^{-1} and 40 kg N ha^{-1} and 20 kg N ha^{-1} could not reach the level of significance. But significant increase in seed yield was observed when nitrogen was increased from 40 kg ha^{-1} to 60 kg ha^{-1}. The lowest grain yield was registedred with 20 kg N ha^{-1} (1665 kg ha^{-1}) and it was not comparable with next level of 40 kg N ha^{-1} (1719 kg ha^{-1}). This might be due to the fact that addition of fertilizers increased the availability of nutrients to plants resulting in profused root growth, and thereby activating greater absorption of these nutrients from soil. Similar results were also reported by Goud *et al*. (2012), Umesh and Shankar (2013) and Singh *et al*. (2016).

The maximum seed yield (1880 kg ha^{-1}) was recorded with application of higher level of phosphorus (100 kg P_2O_5 ha^{-1}) than that of lower levels of phosphorus (75 kg P_2O_5 ha^{-1} and 50 kg P_2O_5 ha^{-1}). But the differences in seed yields did not reach the level of significance between 100 kg P_2O_5 ha^{-1} and 75 kg P_2O_5 ha^{-1}. Phosphorus plays an important pivotal role in the higher yield, by stimulation of root development, energy transformation and metabolic processes in the plants, which in turn, resulted in greater translocation of photosynthates towards the sink development. Ultimately the seed yield plant^{-1} was improved which resulted in higher economic yield (seed yield). Similar trend of results were reported elsewhere by Goud *et al.* (2012), Aher *et al*. (2015) and Ade *et al*. (2018) and Kakade *et al* (2018).

The cost of cultivation increased with increment in the levels of nitrogen and the highest cost of cultivation was recorded in treatment with 80 kg N ha^{-1} (Rs. 37,590 ha^{-1}) than other lower levels of treatments (60, 40 and 20 kg N ha^{-1}) (Table 2). And the lowest cost of cultivation was reported with lower level of nitrogen *i.e.*, 20 kg N ha^{-1} (Rs.36,821 ha^{-1}). The highest gross returns (Rs. 98,433 ha^{-1}) were found with 80 kg N ha^{-1} and was at par with 60 kg N ha^{-1} (Rs. 97,856 ha^{-1}). The lower gross returns were recorded with 20 kg N ha^{-1} (Rs. 85,763 ha^{-1}) which was at par with 40 kg N ha^{-1} (Rs. 88,522 ha^{-1}). Also, the net returns (Rs. 60,843 ha^{-}

^{1}) and the returns per rupee invested (1.62) were recorded higher with highest nitrogen level *i*.e., 80 kg N ha^{-1} and were statistically at par with 60 kg N ha^{-1} (Rs. 60,522 ha^{-1} and 1.62). The lower net returns (Rs. 48,942 ha^{-1}) and returns per rupee invested (1.33) were reported with 20 kg N ha^{-1}. This augment in the gross returns, net returns and the returns per rupee invested was due to increase in the seed yield of pigeonpea and was in close conformity with Sharma *et al*. (2009), Singh *et al*. (2016) and Ramanjaneyulu *et al*. (2017).

Table 2: Seed yield and returns of hybrid pigeonpea (ICPH-2740) as influenced by the levels of nitrogen and phosphorus

Treatments	Seed yield (kg ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Gross returns (kg ha^{-1})	Net returns (Rs. ha^{-1})	Returns per rupee investment
Nitrogen levels (kg ha^{-1})					
20	1665	36821	85763	48942	1.33
40	1719	37077	88522	51445	1.39
60	1900	37334	97856	60522	1.62
80	1911	37590	98433	60843	1.62
SEm±	61.08	-	3145.49	3145.49	0.09
CD (p=0.05)	179	-	9224.6	9224.6	0.3
Phosphorus (P_2O_5) levels (kg ha^{-1})					
50	1684	35800	86736	50936	1.42
75	1833	37206	94386	57181	1.54
100	1880	38612	96808	58196	1.51
SEm±	52.9	-			
CD (p=0.05)	155	-			
Interaction (N × P)					
SEm±	105.79	-			
CD (p=0.05)	NS	-			
CV (%)	10.2	-			

It was recorded that with increase in the levels of phosphorus there was increase in the cost of cultivation. The highest cost of cultivation was recorded with 100 kg P_2O_5 ha^{-1} (Rs. 38,612 ha^{-1}) and the lowest was reported with 50 kg P_2O_5 ha^{-1} (Rs. 35,800 ha^{-1}). The gross returns of Rs. 96,808 ha^{-1} was recorded highest with 100 kg P_2O_5 ha^{-1} which was at par with 75 kg P_2O_5 ha^{-1} (Rs. 94,386 ha^{-1}). And the lowest gross returns were reported with 50 kg P_2O_5ha^{-1} (Rs. 86,736 ha^{-1}). There was an influence of phosphorus levels on the net returns and returns per rupee invested. But the highest net returns (Rs. 58,196 ha^{-1}) and returns per rupee investment (1.51) were obtained with 100 kg P_2O_5 ha^{-1} which was very close to 75 kg P_2O_5 ha^{-1}. Application of 75 kg P_2O_5 ha^{-1} registered highest returns per rupee investment (1.54) which was superior over its higher and lower levels. This increase in the gross returns might be due to increase in the seed yield. These findings are in close conformity with those of Kumar *et al*. (2012), Umesh and Shankar (2013), Singh *et al*. (2016), Ade *et al*. (2018) and Sultana *et al*. (2018).

CONCLUSION

From the above study it was revealed that the growth response and yield were significant with an increment in the both nutrient levels of nitrogen and the phosphorus. The higher values of grain yield (1900 kg ha^{-1} & 1833 kg ha^{-1}), net returns (Rs.60522/- & Rs.57181/-) and B:C ratio (1.62 &1.54) were found with application of nitrogen (60 kg N ha^{-1}) and phosphorus 75 kg P_2O_5 ha^{-1}), respectively. It was concluded that in Krishna agro-climatic zone of Andhra Pradesh, an application of 60 kg N ha^{-1} and 75 kg P_2O_5 ha^{-1} was recommended for getting economically higher grain yield in hybrid pigeonpea.

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