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Maximization of Seed Size Tubers in Potato through Manipulation of Intra Row Spacing, Nitrogen Levels and Crop Duration under Irrigated Condition in Indo –Gangetic Plains of Bihar

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ABSTRACT

A field experiment was conducted during winter season (Oct-Feb) of 2013-14 and 2014-15 with four replications and eight treatments to produce maximum yield of seed size tubers of potato cultivar, "Kufri Pukhraj" by interaction of two nitrogen levels (120 and 150 kg N/ha), two intra row spacing (15 and 20cm), and two crop duration(haulm cutting at 70 and 80 days after planting). The narrow intra row spacing i.e. 15 cm, produced significantly higher yield of seed size grade tubers while wide spacing i.e. 20 cm produced higher yield of large grade tubers. The total tuber yield and tuber number was significantly more in closer spacing. Percent production of seed size tubers to total tubers (both on weight as well as number basis) was higher at narrow spacing. Haulm cutting at 80 days after planting produced significantly higher yield of large grade tuber, while haulm cutting at 70 days after planting, produced significantly higher yield of seed size grades tubers. The total tuber number and tuber yield was significantly higher in haulm cutting at 80 days after planting. Lowest total tuber yield and number was observed in wider spacing with lower nitrogen level and shorter duration. Per cent production (both on weight as well as number basis) of seed size tubers to the total tuber was significantly higher at 60 x 15 cm with 120 kg N /ha and longer crop duration. Plant spacing of 60 x 15 cm with higher fertility levels and shorter crop duration (70 day) was found to be second best treatment in terms of production of seed size tuber.

Keywords: Potato, seed size, spacing, nitrogen haulm cutting dates.

INTRODUCTION

Bihar is an important potato growing state in India contributing about 9.8% of total potato area and 4.2% of the total potato production in the country (Anonymous, 2010). In potato cultivation, seed tuber alone accounts for 40-60% of total cost of cultivation. As the size of seed tuber increases, the cost of cultivation increases. In potato cultivation the harvested produce consists of different grades/sizes of tubers. Suitable crop varieties in different agro climatic zones of India play a crucial role in realizing its production potential (Singh *et al*., 2008). A number of studies conducted in India by various workers (Garg*et al*., 2000 & Singh *et al*., 1993)have amply demonstrated that tubers of 20-75 gram size are suitable for use as planting material for obtaining optimum potato production and is also economical and therefore, considered by many as an ideal seed size. Hence, one of the main objectives of seed production in potato is to maximize the production of healthy disease free seed size (20-75 g) tubers. Potato hybrid Kufri Pukhraj is a high yielding and popular cultivar grown extensively in Bihar and the eastern and northern parts of the country for table purpose. Due to the high yielding nature in Kufri Pukhraj, contribution of large (>70 g) size tuber in the total tuber production is sizeable (> 60 %), when allowed to grow up to the maturity (95-100 days), which is not a desirable attribute from the seed production point of view. Inter and Intra row spacing and crop duration are important cultural factors, which greatly influence the various grades of tubers in produce and also total potato yield (Kushwah and Govindakrishnan, 2003). Nitrogen on the other hand influences significantly the plant growth, tuber initiation and also the number and size of tuber and the total yield (Singh and Raghav, 2000). The situation, therefore, warrants proper adjustment in spacing and haulm cutting dates in relation to nitrogen level for optimizing yield of seed size tubers. Hence, an experiment was conducted to find out proper combination of nitrogen level, spacing and crop duration for maximizing the production of seed size tubers under prevailing agro-climatic conditions of Bihar.

MATERIALS AND METHODS

A field experiment was conducted for two years during winter season (Oct-Feb) of 2013-14 and 2014-15 at Central Potato Research Station, Patna (Bihar) which is situated at 25° 35' N latitude and 085° 05' E, longitudes with an elevation of 52m. The experiment was laid out in randomized block design with four replications and eight treatments to produce maximum number and yield of seed size tubers by interaction of nitrogen levels, spacing and haulm cutting dates (crop duration). The treatment combination consisted of two inter row spacing (S_1 = 15cm and S_2 =20cm), two nitrogen (N) levels (N_1 =120 and N_2=150 kg N/ha) and two haulm cutting dates (H_1= haulm cutting at 70 and H_2 = 80 days after planting). The soils of experimental plot was sandy loam in texture low in organic carbon (0.40%), medium in available N (242.6Kg/ha)

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Phosphorous (18.4Kg/ha) & potassium (274.4 Kg/ha) with pH 7.2.

The inter row spacing of 60 cm was maintained in all the treatments with intra row spacing as per the treatment. The recommended dose of phosphorous (P) and potassium (K) at the rate 60 kg P_2O_5/ha and 80 kg K_2O/ha respectively, was uniformly applied to all the plots. Full P & K and half of N as per the treatments was applied at the time of planting as basal dose and rest half of N was top dressed at the time of earthing up 25 days after sowing.. The sources of N, P & K were Urea, Diammonium Phosphate and Muriate of potash respectively. Well-sprouted tubers of *Kufri Pukhraj* of seed size 40- 50g were planted on 28.10.2013 and 17.11.2014 during first and second year of experimentation respectively. Tubers was covered with 10-12 cm soil layer. Pre-emergence spray of Goal (Oxyflurofen 35 EC) @ 0.5 l/ha was done 4-5 days after planting for controlling weeds. One hand weeding followed by earthing up was done 25 days after planting. One spray of Dithane M-45 (Mancozeb 64%) and three sprays Moximate (Mancozeb 64% + Cymoxanil 8%) @ 2.0 kg/ha of was given to protect the crop from late blight. Recommended agronomic package of practices were adopted for potato cultivation. The haulms were cut as per the treatment at 70 and 80 days after planting and tubers were lifted from the field 10 days after haulm cutting. The produce of each plot was graded into three grades G_1 (<25 g) G_2 (25-75g) and G_3 (>75g) size tubers, weighed and number counted separately. The two year experimental data were pooled and subjected to statistical analysis asdescribed by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of Spacing

Plant spacing significantly influenced the number as well as weight of different grades of tubers. With narrow spacing i.e. 60 x 15 cm^2, the weight and number of G_1, and G_2 grade size tubers were significantly higher while wide intra row spacing i.e. 60 x 20 cm produced higher number and yield of large size (>75g) i.e. G_3 grade tubers (Table 1). The total tuber yield and tuber number was significantly more in closer spacing. Percent production of seed size tubers (G_2) to total tubers (both on weight as well as number basis) was higher at narrow intra row spacing. The multiplication rate of tubers (on number as well as weight basis) was, however, higher at wider spacing as compared to narrow spacing. Crop emergence and number of stems/hill was unaffected due to plant spacing however, number of stems/ha was influenced due to variation in plant spacing. Significantly higher number of shoots/ha was recorded at narrow spacing of 60 x 15 cm. Closer spacing of 60 x 15 cm^2 was associated with increased plant stand, more number of main shoots per unit area which in turn gave an initial competitive advantage to crop which ultimately reflected in higher yield. Singh *et al.* (2015) and Malik and Ghosh (1999) also reported increased yield with closer spacing.

Table 1: Effect of planting geometry, nitrogen dose and crop duration on growth, grade wise tuber number and tuber yield of potato

Treatment	Plant Emergence (%)	Stems /hill	Stems ('000 ha)	Plant height (cm)	Leaves/ plant	Tubers Numbers ('000 ha)			Tuber yield t/ha		
						<25g	<25g	>75g	<25g	25-75g	>75g
S1	97.6	3.70	411.665	40.61	43.05	152.56	2.18	78.72	2.18	17.67	10.51
S2	97.43	3.40	283.75	36.59	34.10	129.25	1.34	87.09	1.34	14.97	11.65
CD(P=0.05)	**NS**	**NS**	**32.42**	**3.8**	**6.16**	**13.6**	**0.35**	**9.58**	**0.35**	**1.6**	**1.05**
HI	97.42	3.60	350.485	39.04	38.68	148.15	1.84	77.11	1.84	16.16	9.61
H2	97.61	3.50	340.765	38.16	38.48	133.67	1.68	88.64	1.68	16.48	12.55
CD(P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**13.6**	**NS**	**9.58**	**NS**	**NS**	**1.05**
N1	97.73	3.50	340.765	35.14	42.64	147.48	1.88	68.60	1.88	16.74	9.66
N2	97.3	3.60	350.485	42.06	34.51	134.32	1.64	97.24	1.64	15.90	12.51
CD(P=0.05)	**NS**	**NS**	**NS**	**3.8**	**6.16**	**NS**	**NS**	**9.58**	**NS**	**NS**	**1.05**

Effect of Nitrogen levels

Increase in Nitrogen level from 120 to 150 Kg N/ha did not influenced significantly the grade wise tuber number as well as yield of G_1 and G_2grade tubers and total tuber yield and number. Increasing nitrogen levels had significant effect on number as well as yield of large size tuber. Significantly, higher yield and number of large size tubers was recorded with 150 kg N/ha (Table 2). The Plant height was significantly higher at 45 days after planting in higher N dose. The percent seed tuber yield to total tuber yield also increased with increasing nitrogen levels and vice-versa. Significant positive correlation was noticed between nitrogen levels and all those yield attributing characters, which were also found to be closely associated with spacing as well. Similar results were also reported by other workers (Singh *et al.*, 2015;Suman*et al.*,2003 and Malik and Ghosh, 1999).

Effect of haulm cutting (Crop duration)

Haulm cutting dates i.e. Crop duration showed significant effect on tuber yield as well as number of different grades of tubers, multiplication rate and percent seed tuber to total tuber yield. Haulm cutting at 80 days after planting produced significantly higher yield and number of G_3 grade tuber, while haulm cutting at 70 days after planting produced significantly higher number of G_1 and G_2 grades tubers. However there was no significant difference due to haulm cutting at 70 and 80

Table 2: Effect of plant spacing, crop duration and nitrogen dose on total tuber number, tuber yield, multiplication rate and percent seed tuber yield of potato

Treatment	Total Tuber Number ('000 ha)	Total tuber yield (q/ha)	Multiplication Rate of seed tuber on Number basis	Multiplication Rate of seed tuber on yield basis	% Seed tuber to total tuber Number	% Seed tuber yield to total tuber Yield
S1	535.67	30.35	2.74	3.53	56.83	58.21
S2	479.59	27.96	3.16	3.99	54.89	53.53
CD(P=0.05)	**42.54**	**2.9**	-	-	-	-
HI	500.93	27.61	3.50	3.77	58.29	59.69
H2	514.28	30.71	3.31	3.69	53.60	52.62
CD(P=0.05)	**NS**	**2.9**	-	-	-	-
F1	503.05	28.28	3.31	3.69	55.03	53.67
F2	512.19	30.05	3.50	3.77	56.77	58.52
CD(P=0.05)	**NS**	**NS**	-	-	-	-

days in respect of tuber yield ofG_1andG_2grades except G_3 grades. But the total tuber yield was significantly higher in haulm cutting at 80 days after planting. This is because haulm cutting at 70 days resulted in comparatively shorter growing periods compared to haulm cutting at 80 days after planting. Similar results have been reported by Garg*et al.* (2000)and Singh *et al.* (1993).

INTERACTION EFFECT

Plant spacing x haulm cutting dates

Interaction effect of plant spacing and haulm cutting dates influenced significantly number and yield of seed size tubers (G_2 grade tubers). Significantly higher yield as well as number of seed size tubers was recorded at narrow spacing (60 x 15 cm^2) and longer crop duration (haulm cutting at 80days) in comparison to wider spacing and shorter crop duration (Table 3). Lowest yield and number of tubers weighing between 25-75 g were recorded in treatment with wider spacing and longer crop duration. Plant spacing of 60 x 20 cm with haulm cutting at 80 days produced significantly more number and yield of large size tuber (> 75g), but lower yield of seed size tubers. Malik and Ghosh (1999) and Garg*et al.* (2000) have also reported similar results.

Table 3: Interaction Effect of plant spacing X crop duration (haulm cutting dates) on seed size tuber yield

Treatment	Seed size Tuber yield (t/ha)			Seed size Tuber number(000/ha)		
	H_1	H_2	Mean	H_1	H_2	Mean
S1	15.92	19.44	17.67	295.99	312.81	304.4
S2	16.40	13.55	14.97	255.35	271.15	263.25
Mean	16.16	16.48		275.67	291.98	
CD(P=0.05)	**1.20**			**25.21**		

Plant spacing x nitrogen level

Significantly higher yield and number of G_1, G_2 and G_3 grade tubers was produced with plant spacing of 60 x 15 cm with higher nitrogen level (Table 4). The total tuber yield was also higher in this treatment. This emphasized that for getting more number and yield of seed tuber up to 75 g size narrow spacing with higher fertility level is suited (Singh *et al.*, 2015).

Table 4: Interaction Effect of plant spacing X nitrogen dose on seed size tuber yield

Treatment	Seed size Tuber yield (t/ha)			Seed size Tuber number(000/ha)		
	N_1	N_2	Mean	N_1	N_2	Mean
S_1	17.05	18.3	17.67	294.42	314.38	304.40
S_2	16.44	13.5	14.97	279.51	246.93	263.25
Mean	16.74	15.90		286.97	280.63	
CD(P=0.05)	**1.26**			**24.81**		

Nitrogen level xcrop duration

Significantly more number and yield of seed size tuber, multiplication rate and percent seed tubers to total tuber was recorded with lower nitrogen levels and haulm cutting at 80 days after planting. On the other hand higher nitrogen levels produced more number and tuber yield of large tubers (>75g) with haulm cutting at 80 days after planting (Table 5). Similar results were reported by Suman *et al.* (2003) and Singh *et al.* (1993).

Table 5: Interaction Effect of nitrogen dose X crop duration (haulm cutting dates) on seed size tuber yield

Treatment	Seed size Tuber yield (t/ha)			Seed size Tuber number(000/ha)		
	N_1	N_2	Mean	N_1	N_2	Mean
H_1	15.67	16.65	16.16	272.07	279.27	275.67
H_2	17.81	15.15	16.48	301.92	282.04	291.98
Mean	16.74	15.90		286.97	280.63	
CD(P=0.05)	**1.31**			**24.54**		

Planting spacing, Nitrogen levels and crop duration

The interaction among plant spacing, nitrogen levels and haulm cutting dates was found to be significant thereby indicating a close link among these factors and suggesting the necessity of proper adjustment in spacing with respect to nitrogen levels and haulm cutting schedules for getting higher yield of seed size tubers (Table 6). Plant spacing at 60 x 15 cm with 150 kg N/ha and longer crop duration (80 days) produced highest tuber yield and number of G_2 (25-75 g) grade tuber (Singh *et al*., 2013 and Singh *et al*., 2015).

Per cent production (both on weight as well as number basis) of seed size tubers (G_2) to the total tuber was significantly higher at 60 x 15 cm with higher nitrogen level and longer crop duration. Plant spacing of 60 x 15 cm with higher nitrogen levels and shorter crop duration (70 day) and Plant spacing of 60 x 15 cm with lower nitrogen levels and longer crop duration (80 day) were found to be second best treatment in terms of production of seed size tuber. Singh *et al.* (1993) and Garg *et al.* (2000) have also reported similar results. This emphasize that with narrow spacing, fertility levels should be reduced with longer crop duration and vice -versa for getting high yield of seed size tubers.

Table 6: Interaction Effect of plant spacing, crop duration and nitrogen dose on seed size tuber yield and number

	Seed size tuber yield (t/ha)				Seed size tuber number (000/ha)			
Treatment	S_1		S_2		S_1		S_2	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
H_1	17.23	17.64	15.93	13.82	291.93	303.25	264.04	243.46
H_2	17.60	18.2	16.2	13.92	308.54	313.86	283.46	262.05
CD(P=0.05)	**1.41**				**26.34**			

This effect in case of high nitrogen with narrow spacing may be attributed to the production of more number of shoots and consequently greater number of tubers because of which the development of tubers was restricted on account of translocation and partition of metabolites to tubers due to shorter growing period. Spacing and haulm cutting schedules, therefore, exerted a counter balance effect on the development of shoots per unit area which is primarily responsible for controlling the number and weight of tubers the two most important yields attributes.

CONCLUSION

It is concluded that for maximization of seed size tubers in potato cultivar Kufri Pukhraj under irrigated Indo –Gangetic plains of Bihar, the intra row spacing should be reduced to 15 cm with either application of 120 kg N/ha and crop duration 80 days or application of 150 kg N/ha and crop duration 70 days.

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