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Agro-techniques for increasing yield potential of potato (*Solanum tuberosum*) under drip irrigation

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ABSTRACT

An experiment was conducted during winter season 2010-11 and 2011-12. The soil of experimental site was clay loam in texture, neutral in soil reaction. The climate of the region is sub humid with an average annual rainfall of 1200-1400 mm. Results revealed that minimum total weed density and total weed dry weight was found under drip irrigation (100% of Open pan evaporation) at all stages during both the years and on mean basis, yield attributes and total tuber yield of potato crop was significantly maximum under drip irrigation (125% of Open pan evaporation) as compared to furrow irrigation. The herbicide Metribuzin (500 g a.i. ha^{-1} PE) proved better among other weed management practices recorded minimum total weed density and total weed dry weight was found at all stages and the maximum yield attributes and total tuber yield of potato crop. Application of 75% N inorganic fertilizer + 25 % N organic (Poultry manure) + PSB + Azotobactor was found non significant to weed control while produced significantly highest yield attributes and total tuber yield.

***Keywords*:** Drip irrigation, integrated nutrient management, potato, weed management

Potato *(Solanurn tuberosurn* L.) is an important crop that requires higher and nearly constant water supply, high soil oxygen diffusion rate, adequate radiations and optimal soil nutrients for proper growth. Proper fertilization and irrigation method of potato therefore, must supply and maintain an optimum level of nutrients all the time within the root zone to realize maximum yield. Irrigation with trickle fulfills all these conditions and is useful for crop like potato that responds well to frequent irrigations and fertilization. Water is the vital source for crop production and is the most limiting factor in Indian agricultural scenario. Though India has the largest irrigation network, the irrigation efficiency has not been achieved more than 40 per cent. Due to water scarcity, the available water resources should be very effectively utilized through water saving irrigation technologies. Hence, further expansion of irrigation may depend upon the adoption of new systems such as pressurized irrigation methods with the limited water resources. Amongst those pressurized irrigation methods, drip irrigation has proved its superiority over other methods of irrigation due to the direct application of water and nutrients in the vicinity of root zone. There are several constraints in potato production, of which weeds often pose a serious problem. Weeds not only compete with crop plants for nutrients, soil moisture, space and sunlight but also serve as an alternative hosts for several insect pest and diseases. Hand weeding and hoeing are common practices followed in India. However, timely weed control may not be possible manually due to non-availability of labours and high rate of wages during peak period of farm operations. Hence, chemical weed control appears to hold a great promise in dealing with effective, timely and economic weed suppression. The overall strategy for increasing potato yields and sustaining them at a high level must include an integrated approach to the management of soil nutrients, along with other complementary measures.

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MATERIALS AND METHODS

The trial was conducted during *Rabi* 2010-11 and 2011-12 at Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G) for increasing yield potential of potato through judicious use of agro-techniques under drip irrigation. The soil of experimental site was clay loam in texture, neutral in soil reaction, low in available N, low in available P and high in available K status. The climate of the region is sub humid with an average annual rainfall of 1200-1400 mm. The crop received 63.7 mm rainfall during 2010-11 and 60.1 mm during 2011-12 crop periods. The crop has sown 10th November during 2010-11 and 14th November during 2011-12. The experiment was laid out in split–split plot design with three replications. The treatments consisted of three irrigation schedule i.e. drip irrigation (125 % of open pan evaporation), drip irrigation (100 % of open pan evaporation) and control (furrow irrigation) as a main plot and four weed management i.e. weedy check, hand weeding (at 25 and 45 DAP), Metribuzin (500 g a.i. ha^{-1} PE) and Chlorimuron + Quizalofop (6 + 50 g a.i ha^{-1}) at 20 Days

after planting as sub plot and four integrated nutrient management i.e. 100 % RDF, 100 % RDF + Micro nutrient (Zinc sulphate 25 kg ha^{-1}), 75 % N inorganic fertilizer + 25 % N poultry manure + PSB + *Azatobactor* and 50 % N inorganic fertilizer + 50 % N poultry manure + PSB + *Azatobactor* as sub- sub- plot. Kufri Chipsona- 2 variety was used for experiment

RESULTS AND DISCUSSION

Growth and development

The results revealed that, drip irrigation (125% of Open pan evaporation) produced significantly higher plant height (22.90 cm), number of leaves $plant^{-1}$(59.82), dry weight of plant (16.81 g) and Crop growth rate (CGR 12.70) as compared to furrow irrigation (19.75 cm, 46.00, 14.16 g and 8.77 respectively), however it was statistically *at par* with drip irrigation (100 % of Open pan evaporation) (22.49 cm, 59.23, 16.58 g and 11.72 respectively) in all growth stages during both the years and on mean basis. The main reason of significantly higher growth of potato in drip irrigation is proper supply of water whatever requirement of crop daily higher accumulation of dry matter in the trickle treatments than the conventional furrow treatment could be the result of increased fertilizer and water-use efficiency in trickle treatments owing to better management of moisture and nutrients. Among weed management practices, Metribuzin (500 g a.i. ha^{-1}PE) registered significantly higher growth parameters, (plant height, number of leaves $plant^{-1}$, dry weight of plant and Crop growth rate (CGR) 24.09 cm, 61.08, 17.30 g and 13.24) as compared to weedy check and rest of the treatments during both the year and on mean basis. The main reason behind this was due to significant impact of Metribuzin (500g a.i ha^{-1} P.E). With the application of this treatment maximum weed was controlled timely, leading to utilization of maximum resources by potato plants. Among integrated nutrient management, application of 75% N inorganic fertilizer + 25% N organic (Poultry manure) + PSB + Azotobactor produced significantly higher values of growth attributes *i.e.* plant height, number of leaves $plant^{-1}$, dry weight of plant and Crop growth rate (CGR) 23.79 cm, 61.46, 18.21 g and 12.69) than other nutrient management practices in all growth stages during both the years and mean basis. This may be due to an increased availability of all macro and micro nutrients to the plant in the presence of biofertilizers and organic manure (poultry manure) and maximum uptake of nutrients through plant due to availability of moisture in root zone due to drip irrigation. Corroboratory results have also been obtained by Ahmed *et al*. (2011), Mukherjee *et al.* (2012) and Sarkar *et al*. (2011) (Table 2).

Weed species

The major weed species existed in the experimental area was *Chenopodium album, Convolvulus arvensis, Melilotus alba, Medicago denticulata, Cynodon dactylon*, and others etc (Table 4.17a). Out of five weed species, *Chenopodium album, Convolvulus arvensis, Melilotus alba, Medicago denticulata* among the broad leaf weeds and *Cynodon dactylon* among grasses were predominant.

Table 1: In the experimental field following weed species or weed flora were found predominant

Sl. No.	Group	Botanical name	Family	Vernacular name
1	Broad leaf weeds	*Chenopodium album*	Fabaceae	Bathua
2		*Convolvulus arvensis*	Convolvulaceae	Hirankhuri
3		*Melilotus alba*	Fabaceae	Safed senji
4		*Medicago denticulata*	Fabaceae	Chinori
5	Grasses	*Cynodon dactylon*	Poaceae	Doob

Weed density and weed dry weight

It was observed that the total weed density was significantly higher under furrow irrigation at all stages during both the years and on mean basis as compared to others. However, minimum total weed density was found under drip irrigation (100 % of open pan evaporation) at all stages during both the years and on mean basis. (Table 3)

The data reveal that significantly lowest weed density and weed dry weight m^{-2} were found with the application of Metribuzin (500 g a.i. ha^{-1}PE) followed by two hand weeding at 25 and 45 DAP compared to weedy check. The maximum weed population and weed biomass was found under weedy check condition which adversely affected the growth and yield of potato crop. Integrated nutrient management

Major weeds found in experiment fields

Chenopodium album

Medicago denticulate

Convolvulus arvensis

Melilotus alba

Cynodon dactylon

Plate I: General view of prominent weeds in experimental site of potato crop

Table 2: Effect of irrigation schedule, weed and integrated nutrient management on plant height, number of leaves, dry weight o plant at 60 days after planting and CGR at 40-60 DAP of potato crop

Treatment	Plant height (cm)			Number of leaves plant^{-1}			Dry weight of plant (g)			Crop growth rate(g day^{-1})		
	2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean
Irrigation schedule												
I_1 – 100% OPE	21.40	23.58	22.49	57.34	61.12	59.23	15.57	17.58	16.58	12.50	10.94	11.72
I_2 – 125% OPE	21.83	23.98	22.90	58.17	61.47	59.82	15.61	18.00	16.81	13.46	11.94	12.70
I_3 – Control (Furrow irrigation)	18.65	20.84	19.75	44.69	47.30	46.00	13.99	14.34	14.16	9.33	8.22	8.77
SEm(±)	**0.15**	**0.11**	**0.10**	**0.25**	**0.26**	**0.21**	**0.09**	**0.17**	**0.11**	**0.25**	**0.27**	**0.26**
LSD (0.05)	**0.61**	**0.44**	**0.39**	**0.99**	**1.01**	**0.82**	**0.36**	**0.70**	**0.44**	**0.99**	**1.04**	**1.01**
Weed management												
W_0 – Weedy check	19.68	21.76	20.72	46.98	49.59	48.28	13.98	14.94	14.46	9.63	8.33	8.98
W_1 – Hand weeding at 25 and 45 DAP	19.70	21.79	20.75	57.99	60.92	59.46	15.68	17.21	16.44	13.01	11.58	12.30
W_2 – Metribuzin (500g a.i ha^{-1}. PE)	22.72	25.45	24.09	59.27	62.89	61.08	16.08	18.51	17.30	13.97	12.51	13.24
W_3 – Chlorimuron (CMS) + Quizalofop (6+50g a.i ha^{-1}) at 20DAP	20.41	22.19	21.30	49.36	53.12	51.24	14.50	15.89	15.20	10.33	9.04	9.69
SEm(±)	**0.29**	**0.27**	**0.26**	**0.41**	**0.47**	**0.39**	**0.11**	**0.11**	**0.10**	**0.11**	**0.12**	**0.11**
LSD (0.05)	**0.86**	**0.82**	**0.78**	**1.22**	**1.40**	**1.18**	**0.34**	**0.35**	**0.30**	**0.35**	**0.35**	**0.34**
Integrated nutrient management												
F_1 – 100% RDF	19.68	20.54	19.53	49.79	52.76	51.27	13.91	15.55	14.73	10.42	9.08	9.75
F_2 - 100% RDF + Micro nutrient (Zinc sulphate 25 kg ha^{-1})	19.70	22.77	21.63	51.66	54.93	53.30	14.42	16.02	15.22	11.28	9.94	10.61
F_3 – 75% N Inorganic fertilizer + 25% N Poultry manure + PSB + *Azotobactor*	22.72	24.93	23.79	59.68	63.24	61.46	17.44	18.97	18.21	13.42	11.97	12.69
F_4 – 50% N Inorganic fertilizer + 50% N Poultry manure + PSB + *Azotobactor*	20.41	22.96	21.91	52.48	55.59	54.03	14.46	16.01	15.24	11.83	10.49	11.16
SEm(±)	**0.25**	**0.24**	**0.21**	**0.30**	**0.35**	**0.29**	**0.15**	**0.20**	**0.15**	**0.19**	**0.19**	**0.19**
LSD(0.05)	**0.70**	**0.70**	**0.61**	**0.85**	**0.99**	**0.83**	**0.43**	**0.57**	**0.43**	**0.54**	**0.55**	**0.54**

OPE: (Open Pan Evaporation)

was found non significant during both the yeas as well as in mean data. Similar findings were also reported by Roder *et al*. (2009) and Karkanis *et al*. (2010) and Mukherjee *et al.* (2012).

Yield attributes and yield

Irrigation schedule positively influenced the yield attributes and yield. The number of stolons plant^{-1}, number of tubers plant^{-1}and tuber yield were significantly higher (28.35, 14.57 and 31.49 t ha^{-1} respectively) under drip irrigation (125 % of open pan evaporation) than control (furrow irrigation 25.37. 10.35 and 21.21 t ha^{-1} respectively) but was at par with drip irrigation (100 % of open pan evaporation 27.91, 14.03 and 30.59 t ha^{-1} respectively) during both the years and on mean basis. The higher yield attributing characters and yield was noticed in the above treatment which might be due to availability of water in sufficient quantity. Among weed management practices, the number of stolons plant^{-1}, number of tubers plant^{-1}and tuber yield were significantly higher (28.85, 14.62 and 29.99 t ha^{-1} respectively) under Metribuzin (500 g a.i. ha^{-1}PE) than weedy check and

Table 3: Effect of irrigation schedule, weed and integrated nutrient management on weed density and weed dry weight in potato at 60 DAP

Treatment	Total weed density at 60 DAP (No. m^{-2})			Total weed dry weight at 60 DAP (g m^{-2})		
	2010-11	2011-12	Mean	2010-11	2011-12	Mean
Irrigation schedule						
I_1 – 100% OPE	2.88 (8.86)	3.15 (11.26)	3.03 (10.06)	3.06 (9.56)	3.09 (10.13)	3.09 (9.85)
I_2 – 125% OPE	3.15 (10.49)	3.58 (14.10)	3.39 (12.30)	3.39 (11.47)	3.37 (11.79)	3.39 (11.63)
I_3 – Control (Furrow irrigation)	4.76 (26.37)	5.52 (36.14)	5.16 (31.26)	4.43 (21.42)	4.81 (25.16)	4.64 (23.29)
SEm(±)	**0.05**	**0.04**	**0.04**	**0.10**	**0.10**	**0.09**
LSD (0.05)	**0.19**	**0.15**	**0.14**	**0.37**	**0.40**	**0.33**
Weed management						
W_0 – Weedy check	5.60 (33.78)	6.55 (46.48)	6.10 (40.13)	5.03 (26.48)	5.32 (29.55)	5.18 (28.01)
W_1 – Hand weeding at 25 and 45 DAP	2.88 (8.05)	3.40 (12.25)	3.16 (10.37)	3.07 (9.33)	3.19 (10.31)	3.14 (9.82)
W_2 – Metribuzin (500g a.i ha^{-1}. PE)	2.09 (4.06)	2.09 (4.36)	2.11 (4.21)	2.63 (6.70)	2.45 (6.24)	2.57 (6.46)
W_3 – Chlorimuron (CMS) + Quizalofop (6+50g a.i ha^{-1}) at 20DAP	3.82 (14.62)	4.28 (18.92)	4.07 (16.77)	3.78 (14.10)	4.07 (16.67)	3.93 (15.39)
SEm(±)	**0.05**	**0.11**	**0.07**	**0.07**	**0.10**	**0.07**
LSD (0.05)	**0.14**	**0.33**	**0.20**	**0.21**	**0.31**	**0.22**
Integrated nutrient management						
F_1 – 100% RDF	3.73 (16.22)	4.22 (21.41)	3.99 (18.82)	3.73 (14.78)	3.90 (16.75)	3.83 (15.77)
F_2 - 100% RDF + Micro nutrient (Zinc sulphate 25 kg ha^{-1})	3.57 (14.93)	4.09 (20.25)	3.85 (17.59)	3.64 (14.19)	3.71 (15.16)	3.68 (14.67)
F_3 – 75% N Inorganic fertilizer + 25% N Poultry manure + PSB + *Azotobactor*	3.52 (14.82)	3.96 (20.08)	3.76 (17.45)	3.55 (13.81)	3.70 (15.51)	3.65 (14.66)
F_4 – 50% N Inorganic fertilizer + 50% N Poultry manure + PSB + *Azotobactor*	3.58 (14.99)	4.05 (20.26)	3.83 (17.62)	3.59 (13.82)	3.73 (15.34)	3.67 (14.58)
SEm(±)	**0.05**	**0.09**	**0.06**	**0.06**	**0.08**	**0.06**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Note : The figures in parenthesis indicate the original values, square root transformation is applied.

Table 4: Effect of irrigation schedule, weed and integrated nutrient management on number of stolons, tubers and yield of potato

Treatment	Number of stolons plant^{-1}			Number of tubers plant^{-1}			Tuber yield (t ha^{-1})		
	2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean
Irrigation schedule									
I_1 – 100% OPE (Open Pan Evaporation)	26.47	29.38	27.91	12.43	15.63	14.03	30.16	31.24	30.59
I_2 – 125% OPE	26.98	29.72	28.35	13.00	16.13	14.57	31.02	32.01	31.49
I_3 – Control (Furrow irrigation)	24.37	26.39	25.37	9.15	11.56	10.35	20.74	21.68	21.21
SEm(±)	**0.13**	**0.36**	**0.17**	**0.23**	**0.18**	**0.20**	**0.23**	**0.24**	**0.23**
LSD (0.05)	**0.53**	**1.41**	**0.66**	**0.90**	**0.72**	**0.78**	**0.91**	**0.93**	**0.92**
Weed management									
W_0 – Weedy check	24.44	26.19	25.30	10.14	12.90	11.52	24.81	25.68	25.25
W_1 – Hand weeding at 25 and 45 DAP	26.35	28.88	27.59	12.30	15.04	13.67	28.57	29.48	28.96
W_2 – Metribuzin (500g a.i ha^{-1}. PE)	26.86	30.83	28.85	12.95	16.28	14.62	29.51	30.60	29.99
W_3 – Chlorimuron (CMS) + Quizalofop (6+50g a.i ha^{-1}) at 20DAP	26.11	28.10	27.10	10.71	13.54	12.13	26.33	27.47	26.87
SEm(±)	**0.13**	**0.24**	**0.16**	**0.12**	**0.14**	**0.13**	**0.19**	**0.20**	**0.20**
LSD (0.05)	**0.39**	**0.74**	**0.49**	**0.37**	**0.43**	**0.39**	**0.57**	**0.59**	**0.59**
Integrated nutrient management									
F_1 – 100% RDF	24.82	27.17	25.97	10.50	13.49	12.00	24.85	25.82	25.30
F_2 - 100% RDF + Micro nutrient (Zinc sulphate 25 kg ha^{-1})	25.51	28.11	26.81	10.87	13.82	12.35	26.61	27.63	27.08
F_3 – 75% N Inorganic fertilizer + 25% N Poultry manure + PSB + *Azotobactor*	27.70	30.52	29.11	13.55	16.54	15.05	30.45	31.58	30.96
F_4 – 50% N Inorganic fertilizer + 50% N Poultry manure + PSB + *Azotobactor*	25.73	28.19	26.95	11.18	13.91	12.55	27.31	28.23	27.73
SEm(±)	**0.16**	**0.24**	**0.17**	**0.18**	**0.17**	**0.17**	**0.273**	**0.26**	**0.26**
LSD (0.05)	**0.45**	**0.69**	**0.49**	**0.52**	**0.49**	**0.48**	**0.769**	**0.75**	**0.73**

rest of the treatments this may due to timely weed control and which reduce crop weed competition and increase availability nutrients and water to plants. Significantly higher yield attributing characters *i.e.* number of stolons, tubers and tuber yield (29.11, 15.05 and 30.96 t ha^{-1} respectively) was found under treatment 75% N inorganic fertilizer + 25 % N organic (poultry manure) + PSB + *Azotobactor* than other nutrient management practices during both the years and on mean basis (Table 4) this result is due to availability of essential major and micro nutrient thorough the crop growth stages . These findings are in agreement with those reported earlier by Yadav *et al.* (2011), Badra *et al.* (2012), Kumar *et al.* (2012) and Sahebi *et al.* (2012).

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